Galileo's Images Fresh from Jupiter

ASTRONOMY®

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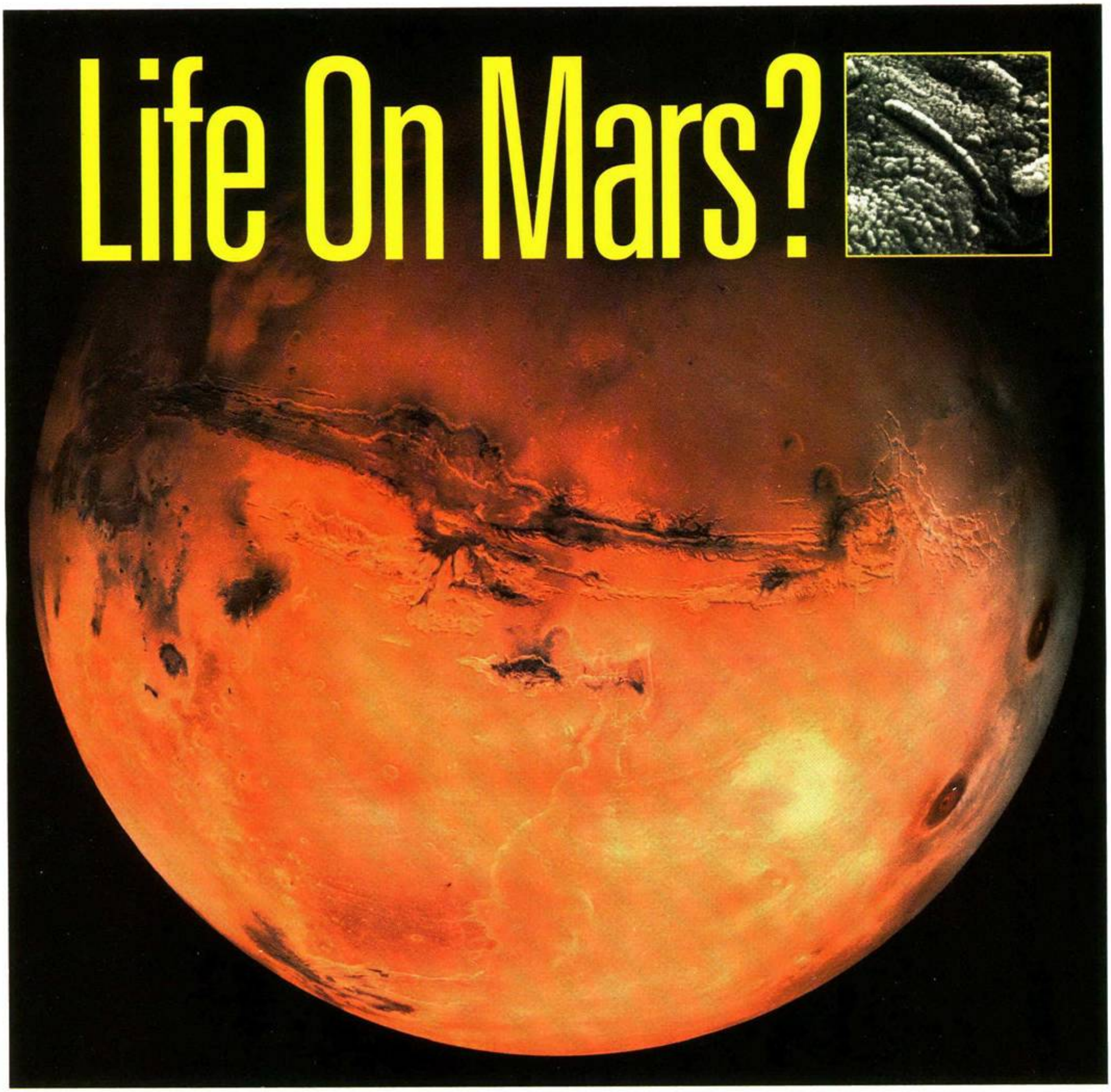
Chaos When Galaxies Collide

Life On Mars?



- How to Watch this Winter's Meteors
- Explore Infant Stars along the Milky Way

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12"
MEADE LX200 EMC
10"
MEADE LX200 EMC
7"
MEADE LX200 EMC
8"
MEADE LX200 EMC
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MEADE LX200

MEA

LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

LX50

Advanced technology at the most affordable prices ever.

LX50 models shown with optional Field Tripod.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

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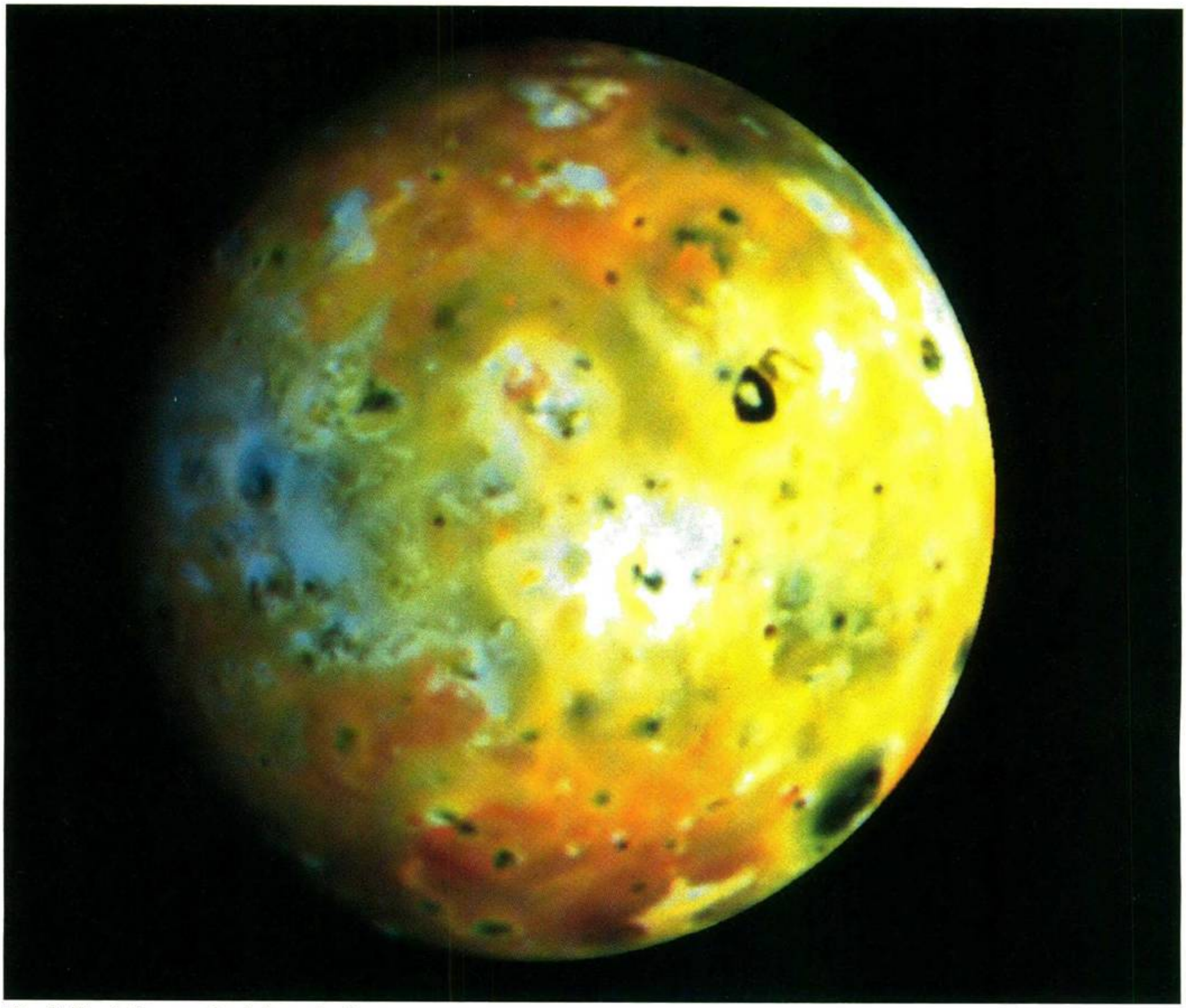

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Was There Life on Mars?

The discovery of possible fossilized remains of martian microbes in a meteorite from Antarctica galvanized the world, and initiated a scientific debate that may take years to settle. *Robert Naeye.*

Cover Photo
U. S. Geological Survey

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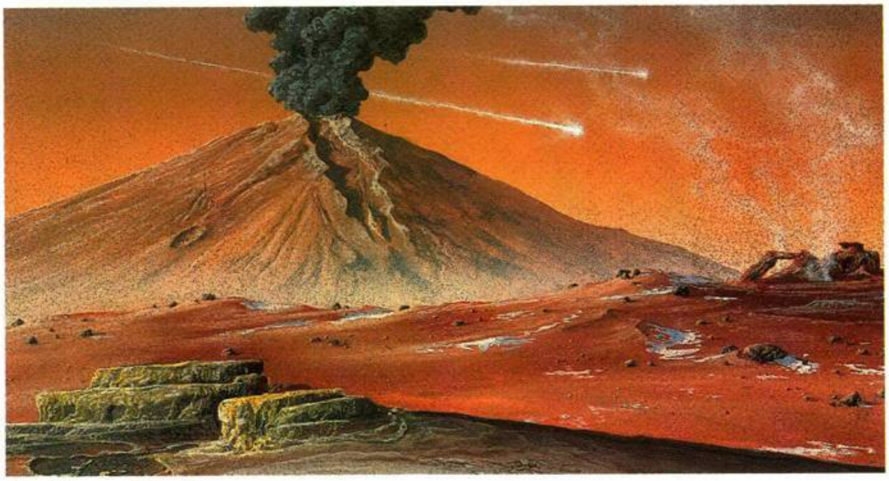
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84 Exploring Cassiopeia's Bright Clusters

Nearly overhead on November evenings, this stunning constellation holds dozens of the Milky Way's finest star clusters. *Robert A. Garfinkle.*

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The next three months offer three meteor showers worth your attention: the possibly stormy Leonids, the always reliable Geminids, and the frigid-weather Quadrantids. *Phil Bagnall.*

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BEHIND THE SCENES

ASTRONOMY's new leadership team

Publishing is a people business. It's one of the few remaining professions where the talent, energy, and creativity of the people involved have a profound impact on the end product. So, I'm pleased to introduce two talented people who have recently joined the staff of ASTRONOMY. And I'd also like to announce the promotion of one of our veteran staff members.

Bonnie Gordon

Bonnie Gordon

ASTRONOMY: William Zuback

Dave Eicher

ASTRONOMY: William Zuback

Carole Kramer

Editor, Bonnie Gordon. About the time you read this, Bonnie, a highly respected science journalist, will be assuming her duties as the magazine's new editor. She brings to this magazine a wealth of experience she's acquired working in high level positions at major science magazines. For the past six years she was editor of *Sea Frontiers*. Prior to that she served as health director for *Self* Magazine, executive editor of *Health* and senior editor of *Science 80–86*.

Managing editor, Dave Eicher. In the September issue we announced the promotion of Dave Eicher to senior editor. After a very brief stint as senior editor, Dave is now the magazine's new managing editor. Dave, who has been on the staff of ASTRONOMY for 15 years, has authored more than 160 articles, written seven books, and is well-known in the amateur astronomy community.

Art director, Carole Kramer. Carole, a talented graphic artist, began her new career here in July. Her prior experience includes teaching graphic design at the Milwaukee Institute of Art and Design, art directing *Quality Progress* Magazine and designing children's books for Raintree Publishers.

The addition of this new talent, plus the pool of talent we already have, will result in an improved magazine over the months and years ahead. Bonnie, Dave, Carole, and the entire staff will be striving to make a good magazine even better. They will bring you a magazine that's well crafted, contains balanced coverage of all aspects of astronomy, articles by the best writers they can find, and reports on the latest astronomical news in a timely fashion. They will also work toward making the complex field of astronomy understandable and enjoyable to a broader audience.

Improving a magazine takes time, so don't expect changes in the next few issues. However, by this time next year you can expect that the content, readability, and look of this magazine will have moved forward dramatically. As Bonnie and her staff work toward taking this magazine to a higher level of reader satisfaction, let us know which changes you like and which ones you don't care for. Together we can create a "new" ASTRONOMY for the new millennium.

Russ Larson

Russ Larson
Publisher

ASTRONOMY®

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The Audit Bureau

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MEADE 8" LX10

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4- pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

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Meade Pictor 208XT

AUTOGUIDER/IMAGER

complete ***$495***

Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot; Dumbbell Nebula (M27), 12" LX200, John Hoot.

Meade Pictor 216XT

AUTOGUIDER/IMAGER

complete ***$695***

Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Comet Hyakutake, 8" LX200 with f/6.3 Focal Reducer, John Hoot; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.

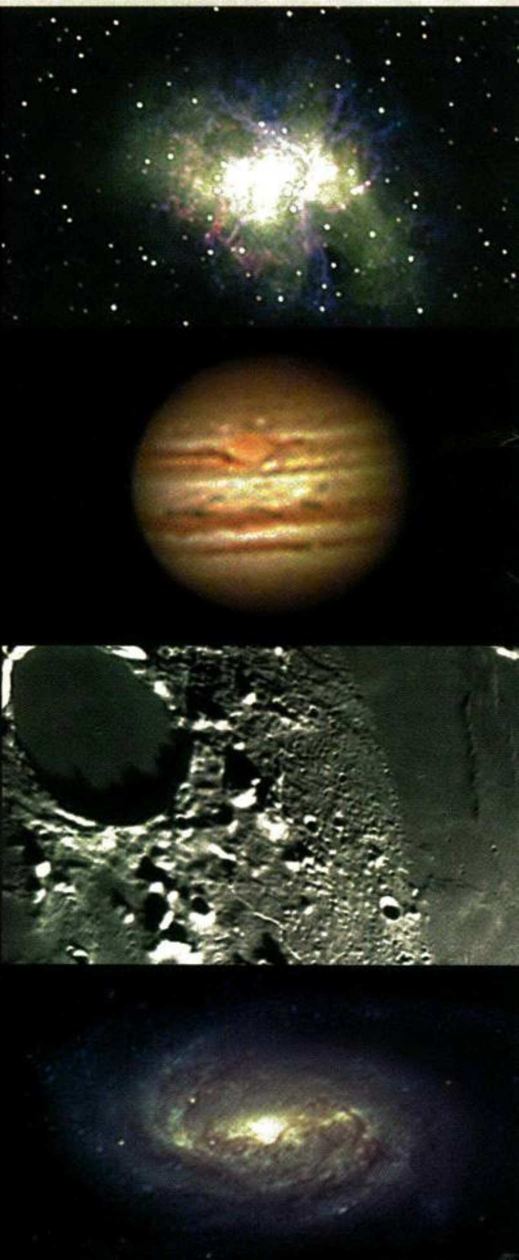
Meade Pictor 416XT

AUTOGUIDER/IMAGER

complete ***$1695***

includes $800 Meade CCD Equipment System

Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker; NGC 2903, 25" reflector, Jack Newton.



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XT-SERIES CCD IMAGERS

Now you can buy a high-performance Meade® CCD imager for as little as *$495!*

Meade Instruments has just made high-performance CCD imaging affordable for everyone. New Meade Pictor XT-Series imagers offer more features, more high-resolution imaging, and more easy-to-follow menu options than any imagers ever made available. *You can pay $500 to $1000 more for competing CCD units and still not obtain the advanced capabilities of Meade XT-series imagers.* Choose the Meade imager that is right for your budget and applications. *All models are supplied complete and ready-to-use and are available for immediate delivery:*

Pictor 208XT Autoguider/Imager

One of the most revolutionary astronomical products ever developed, the Meade Pictor 208XT has opened up the field of CCD imaging potentially to tens of thousands of serious amateurs worldwide. In the 208XT astronomers have at last a truly remarkable, high-performance imager at an amazingly low price. One look at the Pictor 208XT will convince its owner that he or she has purchased a product of exquisite quality, an almost magical electronic instrument that produces on the PC display, in 2 or 3 minutes, fine, high-resolution images of thousands of deep-space objects or, in seconds, of the Moon and planets.

Specifications: Includes autoguider/imager body (4" dia.) with digital readout of operating data and with Texas Instruments TC-255 CCD chip (3.30 x 2.40mm; 336 x 242 pixels; pixel size: 10µm - square); 8-bit A/D conversion for 256 gray-levels in the image; 1.25" barrel for standard eyepiece-holders; cords for connection to telescope and PC. Software features: image transfer and display; contrast control; smoothing/sharpening filters; automatic and manual exposure levels; automatic dark-field exposure and flat-field sequence; pixel binning. Operating manual. **$495.** (+ $20 packing and shipping in 48 states)

Pictor 216XT Autoguider/Imager

By far the finest autoguider/imager ever made available in its price class, the 216XT enables advanced imaging applications. Identical in operating characteristics to the 208XT, the Pictor 216XT includes two additional important features at moderate additional cost: (a) A 16-bit analog-to-digital converter (compared to the 208XT's 8-bit converter), permitting 65,536 gray levels for smoother, more natural images; (b) External connectors and onboard software that allow the 216XT to be used with the Pictor 616 Color Filter System for tri-color imaging. *The Pictor 216XT is the only imager available with these capabilities within $500 of the 216XT's price. The 216XT is all the imager ever required by the majority of amateur astronomers.*

Specifications—Includes autoguider/imager body (4" dia.) with digital readout of operating data and with Texas Instruments TC-255 CCD chip (3.30 x 2.40mm; 336 x 242 pixels; pixel size: 10µm - square); 16-bit A/D conversion for 65,536 gray-levels; 1.25" barrel for standard eyepiece-holders; cords for connection to telescope and PC. Software features: same as for Pictor 208XT *(above),* and with software provision for attachment to Pictor 616 Color Filter System. Operating manual. **$695.** (+$25 P & S)

Pictor 416XT Autoguider/Imager

The amateur astronomer's dream of professional-level imaging capability, the Meade Pictor 416XT is armed with the powerful Kodak KAF-0400 CCD microchip and the latest in Meade operating software. The most advanced CCD system available at under-$5000, and yet one of the easiest to use, the 416XT is capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes.

For a limited time the Pictor 416XT includes **at no additional charge** the $800 Meade CCD Equipment System *(see photo),* with the **Meade Pictor 201XT CCD Autoguider** ($395); **Meade CCD Off-Axis Guider System,** with 1.25" and Schmidt-Cassegrain attachment barrels ($119); **Meade CCD Image-Orientation Adapter** ($35); **Meade Epoch 2000ip Image Processing Software** ($199); **Meade Deluxe Carrying Case** ($59).

Specifications—Includes autoguider/imager body (5" dia.) and control box with digital readout display and keypad; incorporates Kodak KAF-0400 CCD chip (6.90 x 4.60mm; 768 x 512 pixels; pixel size: 9µm - square); 16-bit A/D conversion for 65,536 gray-levels in the image; CCD Equipment System, described above; SCSI interface for one-second downloading; 1.25" barrel for standard eyepiece-holders; cords for connection to telescope and PC. Software features: same as for Pictor 208XT *(left),* and with software provision for attachment to Pictor 616 Color Filter System. Operating manual. **$1695.** (+$40 P & S)

Pictor 416XT imagers are shipped at no additional charge with the $800 Meade CCD Equipment System.

All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ For safety reasons AC-powered personal computers should be used indoors only. ■ For your free copy of the 94-page **Meade 1996 General Catalog** write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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LUMICON, Livermore, CA, Orders: 800-767-9576; Information: 510-447-9570

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MEADE STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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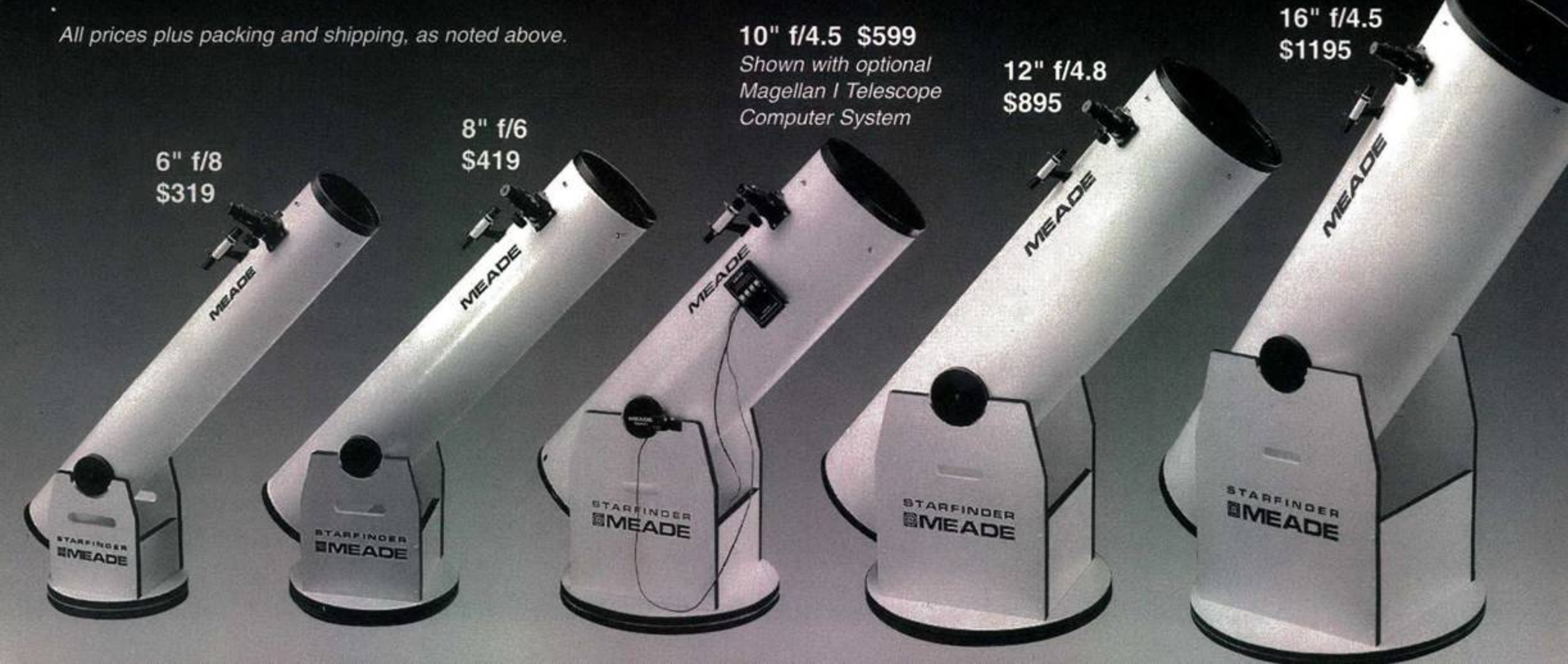
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

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STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

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MAGELLAN II
COMPUTER-CORRECTOR
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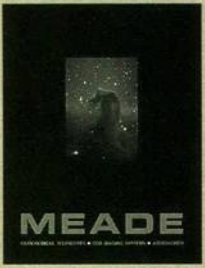
Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16". . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*



The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 94-page Meade 1997 General Catalog.

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To Order: Contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.

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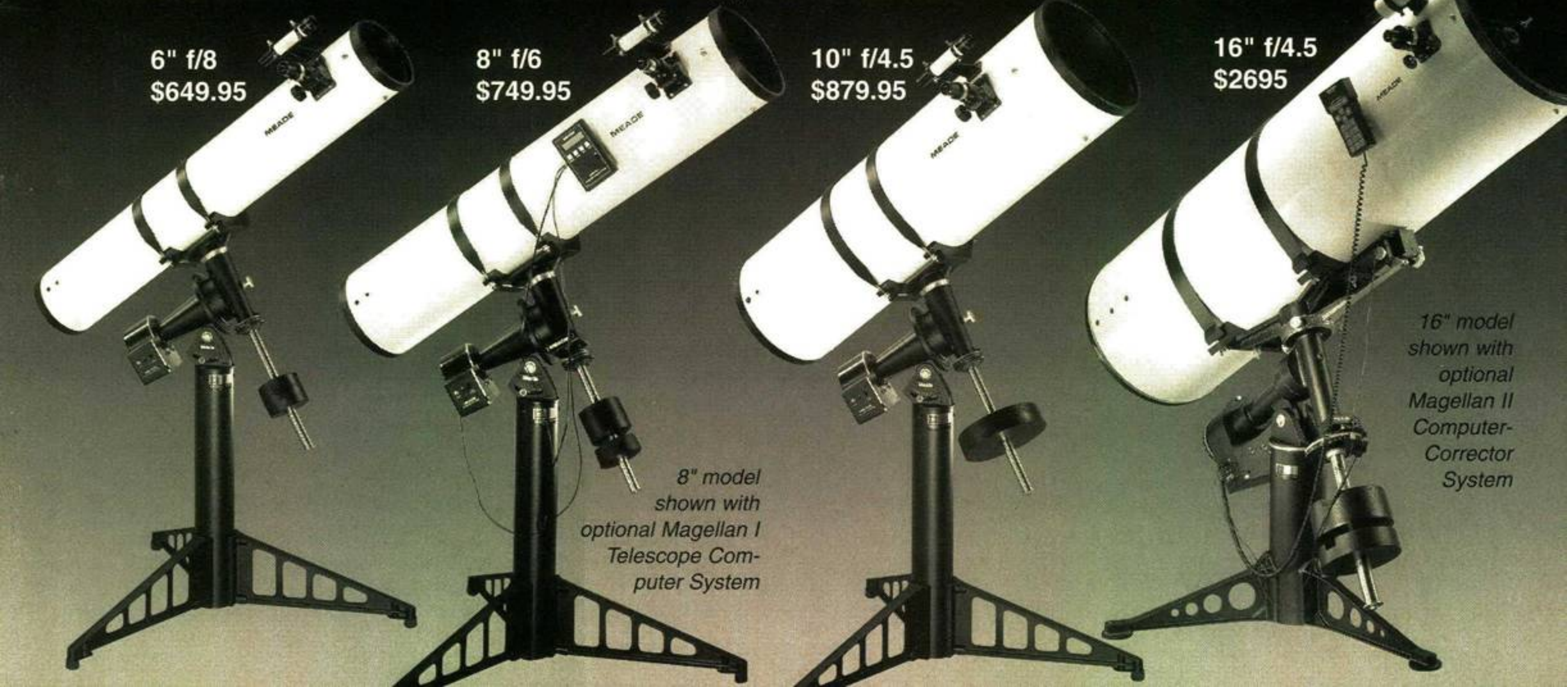
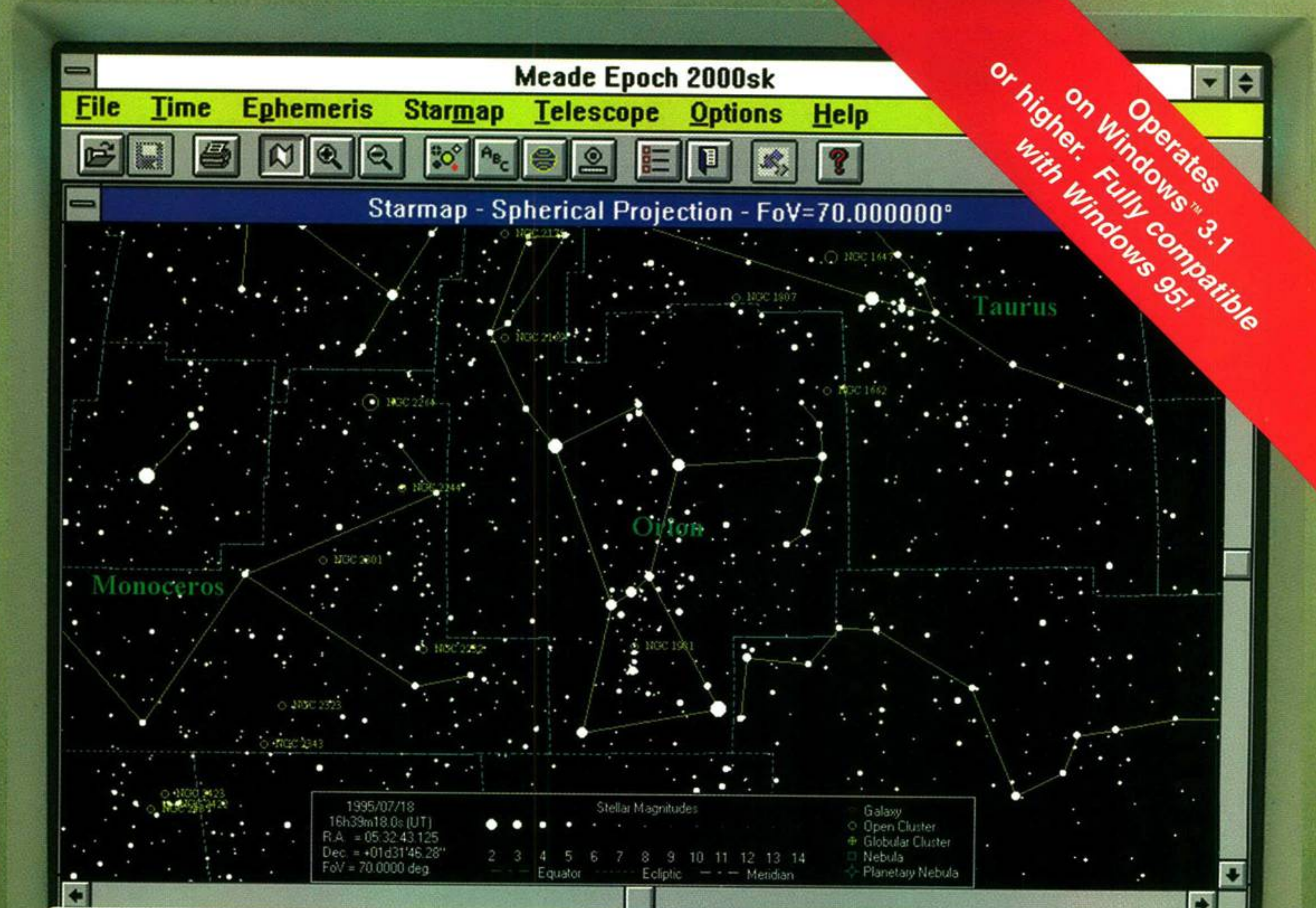
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

Operates on Windows™ 3.1 or higher. Fully compatible with Windows 95!


Meade Epoch 2000sk
File
Time
Ephemeris
Starmap
Telescope
Options
Help
Starmap - Spherical Projection - FoV=70.000000°
Taurus
Orion
Monoceros
NGC 2129
NGC 1647
NGC 1807
NGC 2169
NGC 1662
NGC 2264
NGC 2244
NGC 2301
NGC 2252
NGC 1981
NGC 2323
NGC 2343
NGC 2423
NGC 2420
Stellar Magnitudes
2 3 4 5 6 7 8 9 10 11 12 13 14
Equator
Ecliptic
Meridian
Galaxy
Open Cluster
Globular Cluster
Nebula
Planetary Nebula
15:32:34
R.A. 01:09:39.072
Dec. +05°55'44.61"

1995/07/18
16h39m18.0s (UT)
R.A. = 05:32:43.125
Dec. = +01d31'46.28"
FoV = 70.0000 deg.

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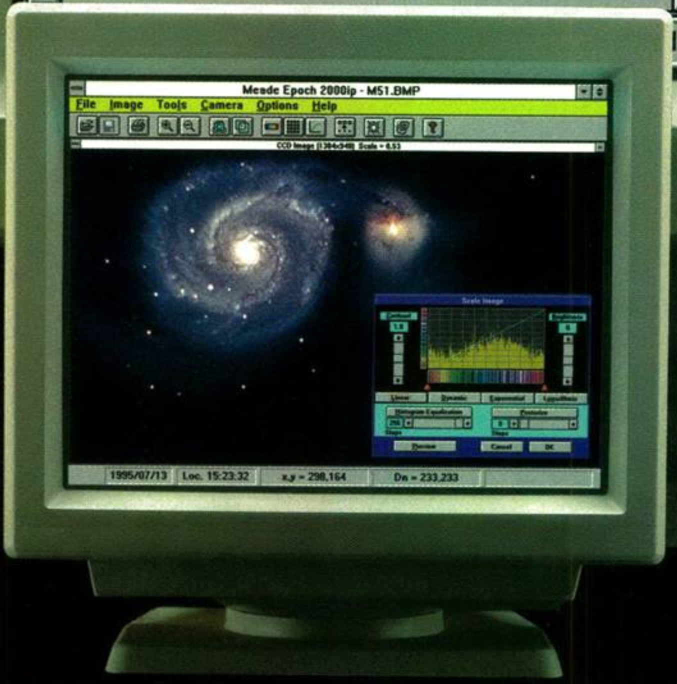
Meade Epoch 2000ip - M51.BMP
File
Image
Tools
Camera
Options
Help
Scale Image
Preview
Cancel
OK

1995/07/13 | Loc. 15:23:32 | x,y = 298,164 | Dn = 233,233

MEADE® EPOCH 2000®

The most powerful astronomical software ever made available can now be yours for only $149!

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Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

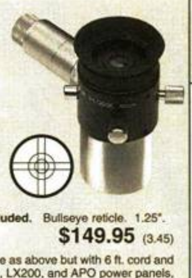
#929 or **#930**, each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

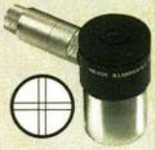
For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls
50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

HOW TO ORDER

- Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

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ASTRO LETTERS

Applause for Lunar "Windows"

I applaud Peter Bond's "Lunar Windows to the Heavens" (September 1996) that detailed the tremendous potential of Moon-based astronomy. The primary purpose of our valiant effort to put men on the Moon in the sixties should have been to exploit its properties for astronomical research instead of returning rock samples and trumping the Russians. Instead, the lunar program was dropped, and almost three decades and billions of dollars were wasted on the meager science of the Shuttle program. Had NASA continued to pursue lunar astronomy, most of the projects envisioned by Bond could already be reality. — *William Fusfield, Pittsburgh, Pennsylvania*

Radio Astronomy In a Vacuum?

I enjoy ASTRONOMY and consider it a necessary observing tool. There is, however, a vacuum where radio astronomy is concerned. As a child I was introduced to astronomy at the National Radio Astronomy Observatory in Green Bank, West Virginia. While I'm sure more of your readers enjoy visual observing, there are those of us who enjoy "listening" to the stars as well. Becoming a radio astronomer may be out of my league, but amateur radio astronomy is not. — *Jason Shinn, North Lawrence, Ohio*

Angry About Funding Cuts

We are only beginning to find extrasolar planets and we need to study them further, yet the government is cutting funding to telescopes, both visible and radio, that might aid in the research. Financial cuts were made to the "Big Ear" in Ohio, which conducts SETI research, and now to some of the telescopes on Kitt Peak. Additionally, NASA's funding is threatened. I revel in the possibilities that these new discoveries offer and am angry that some scientists will not be able to continue their work. — *Kassandra Mullan, Goodyear, Arizona*

Gray Whales and Hyakutake

By chance, from mid-March to mid-June, I became quite intimate with the nightly moods and movements of Hyakutake while monitoring the northbound spring migration of Gray whales and seabirds at Point Piedras Blancas Lighthouse in San Luis Obispo County, California. "Hyakutake's Spring Surprise" (July 1996) complements my experience and daily field notes/journal, which included a special paragraph each day about Hyakutake.

Thanks to ASTRONOMY, I now have a wonderful set of photos to go with those notes — an addition to the permanent record I can refer to at any time.

Can Hale-Bopp measure up? Same time, same place, 1997. I'll be watching! — *Richard Rowlett, Seattle, Washington, pagodroma@aol.com*

Spark Interest at an Early Age

Prior to reading "Journey to the Outer Limits" (August 1996), I thought reaching other stars was impossible. I'm now intrigued by the possibilities that were presented. My interest extends to the classroom where I teach kindergarten. I plan an annual "star party" for our school district (grades K-12), because I believe that sparking interest at an early age is the key for developing some of the amazing scientific feats that were mentioned in the article. — *Peggy Wethered, Nampa, Idaho, 72056.715@CompuServe.com*

ASP to Network Astronomy Instructors

The Astronomical Society of the Pacific (ASP) is establishing a network of instructors who teach astronomy in community colleges or small colleges where research activities are not required of faculty.

Aided by a small grant from NASA's IDEA program, the ASP is beginning by surveying such instructors, establishing a mailing list for information exchange, and holding meetings to discuss issues of mutual interest. Interested instructors may request a survey by e-mailing or writing to Andrew Fraknoi, ASP, 390 Ashton Avenue, San Francisco, California 94112, fraknoi@admin.fhda.edu.

Many Readers Accepted the Free-Form Challenge

ASTRONOMY's "Free Form Observing" (August 1996), inspired many readers to observe and identify the deep-sky objects presented. Congratulations to all who made the attempt and kudos to Steve Gottlieb of Albany, California. He was the first to identify all of the following objects correctly:

"Bright Globular," M22; "False Comet," NGC 6712; "Surprise Planetary," IC 1295; "Eye in the Sky Planetary Nebula," NGC 6804; "Mini Pleiades," Cr 399 (the "Coat hanger"); "Loose Globular," M71; "Star Scattering," Harvard 20; "Apple Core," M27; "Wraiths," Veil Nebula; "Faint Planetary," NGC 7048; and the "3-D Cluster," NGC 7789.

Initially I was annoyed by your article because no object names were given, but soon I became caught up in the game of identifying them. A few objects I already knew; others puzzled me. I thought the level of difficulty was just right. The easy ones provided markers along the way to the more difficult objects, and the photographs were a nice aid in confirming some of them. I enjoyed the descriptions, and in order to be successful on this treasure hunt I had to pay close attention to them. — *Larry Quimby, Long Beach, California, lquimby@lausd.k12.ca.us*

Correction

"The Lost Ring of Saturn" (AstroForum, September 1996) made references to "Ring P" that should have been "Ring F," and Walter Feibelman is not a "German astronomer." He is an American astronomer at Goddard Space Flight Center. The editing retained all the essential elements present in the original essay. Well done, and thanks for printing the stuff.—*Tom Dobbins, Coshocton, Ohio* □

ASTRONOMY welcomes feedback. Send it to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet use letters@astronomy.com. Letters may be edited for space and clarity.

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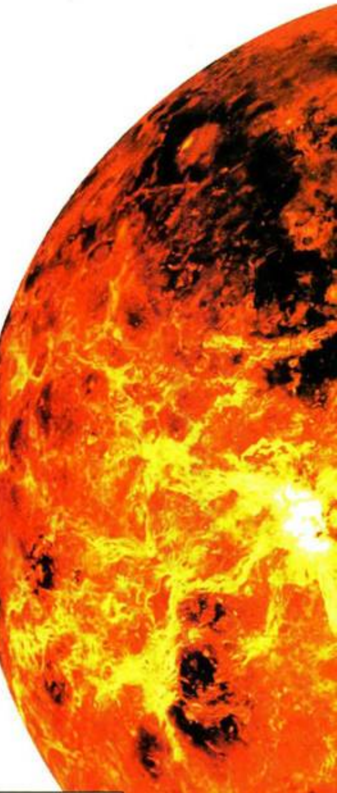

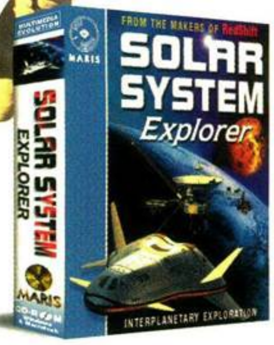

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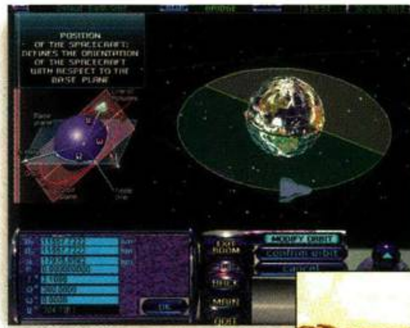

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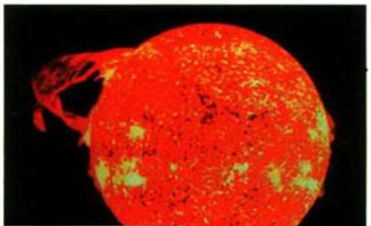

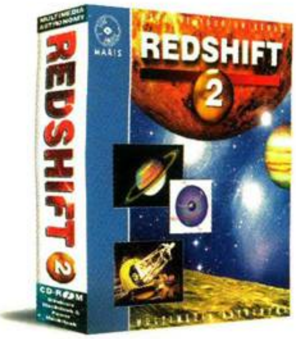

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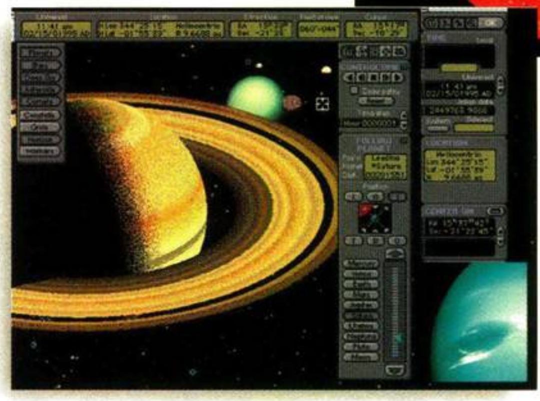

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ASTRO FORUM

Mars on Earth!?

by Claudio Veliz

"The President has been shot!" "A bomb exploded in Oklahoma City!" "A 747 went down south of Long Island!" Recall these headlines? For the rest of our lives, many of us will remember the "where we were" factor regarding such events.

But how many will remember the moment when possible signs of life were found inside an ancient Martian meteorite? How might this news be rated in a thousand years? In that unimaginable future, few may know of the historical figure John F. Kennedy, or recall that terrorists wreaked havoc in the late second millennium. In a thousand years, however, I suspect it may not be so easy to forget this little meteorite.

The discovery of ALH84001 was at first unremarkable. (ALH = where it was found, "Allan Hills" Antarctica; [19] "84" = year, and "001"= the first numbered there during the year. Watch for the vanity plates.) But a couple of years ago the little morsel was determined to be possibly from more significant origins than "merely" space. Now the meteorite is undergoing the "dissection" stage of its journey — being thoroughly prodded, sliced, and analyzed chemically. Scientists with electron microscopes are observing it closely, primarily to determine if that little wormy thing we've all seen in the news indeed has a cell wall. That, according to the pros, would clinch it; then it's party time.

David S. McKay of NASA's Johnson Space Center in Houston headed a research team that claims to have identified polycyclic aromatic hydrocarbons (PAHs) and other microscopic evidence supporting the possibility of past Martian microbial life inside this Antarctic meteorite. The meteorite is one of 12 so far, thought to be flack thrown from Mars during one of millions of asteroidal/cometary impacts throughout its history. The force during the impact of the perpetrating asteroid was sufficient to pass on escape velocities to many of the once restful chunks of rocks on, or near, Mars' surface, sending them into solar orbit. After doodling around for millions of years, a few of these meteoroids were "vacuumed" by Earth's gravity, one of which smashed onto Antarctica's surface as a little stone eager for fame. The 4.2-pounder had to wait 13,000 chilly years before being caressed in a warm researcher's hand.

This notion of finding a meteorite on Earth, with evidence of life-stuff stuck inside it and originating from another planet, is not new. One recent and prophetic example of such

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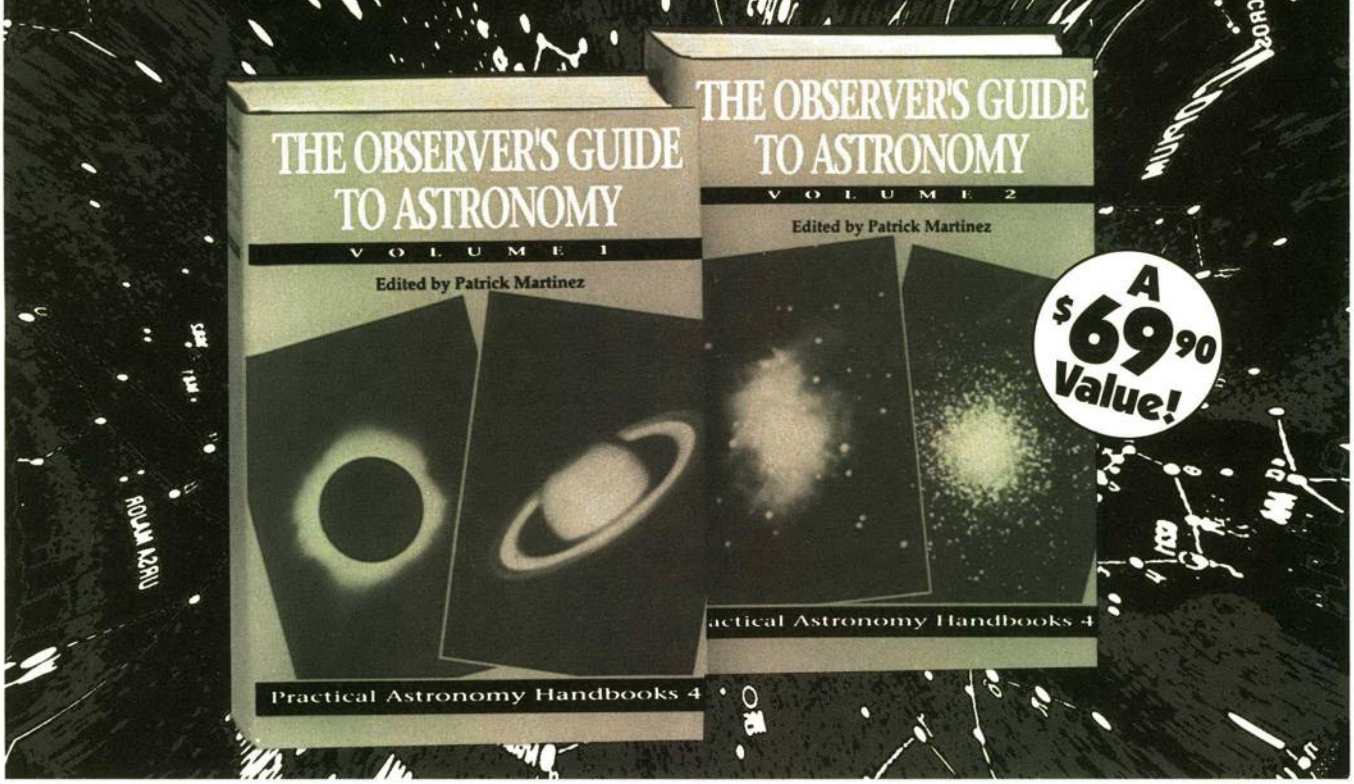
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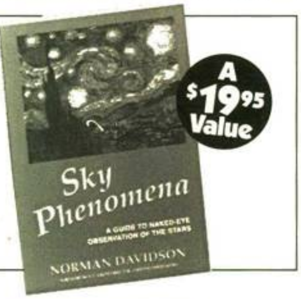

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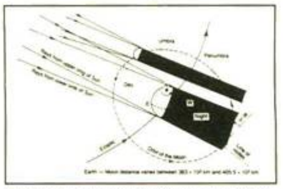

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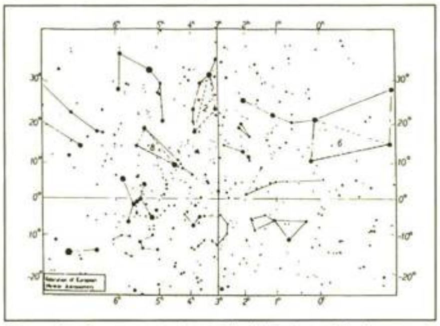

Example of a gnomonic chart. The distortion of the Square of Pegasus at top right is particularly noticeable.

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a scenario is described in Paul Davies' informative book *Are We Alone?* (HarperCollins, New York, 1995). It begs the question — if there is, indeed, evidence for life on Mars, past or present, could it be similar to our own? Will we find the same chemistry in humans as in wiggly Mars critters?

There are skeptics, of course. Jack D. Farmer of NASA's Ames Research Center, called the evidence "interesting but not convincing." The skeptical view states that chemical interactions can, under particular circumstances, show characteristics similar to those of primitive life.

The net result of the claim of evidence for Martian life and the resulting skeptical response is the instigation of efforts to confirm it one way or the other; not only further investigation on this particular meteorite, but discussions about amending imminent Mars missions.

What is it about all this that interests us? Why does the possibility of life elsewhere, however primitive, fascinate even the scientifically challenged public? The answer may lie in more than one place. A National Science Foundation survey recently indicated that 87% of Americans, after all, were considered "scientifically illiterate." Is it any wonder that NASA administrator Daniel S. Goldin found it necessary to clarify, with a serious face, that nothing of the "little green men" variety was being addressed by the nature of this discovery?

The fascination depends on who we are. How we receive information can influence our interpretation of its significance. The vast majority of people employed in the world of "the media" have liberal arts backgrounds, and aren't typically science majors. The treatment of this scientifically detailed story by many newspapers and local television stations, at least in the New York area, has been infused with an uncomfortable, self-conscious, humorous tone or simply uninformed of the most basic scientific knowledge. I watched open-mouthed while a New York anchorwoman stated,

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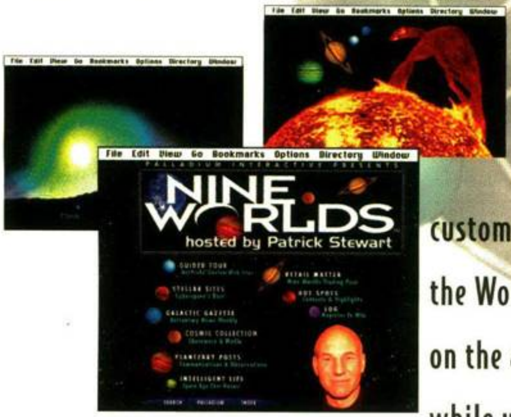

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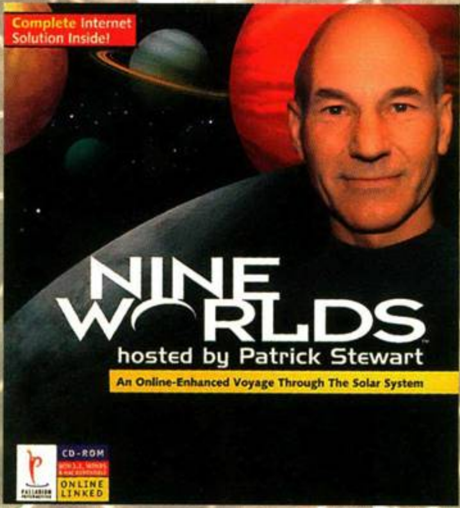

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Essential observing guides for beginning amateur astronomers
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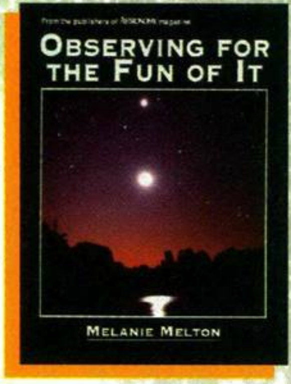

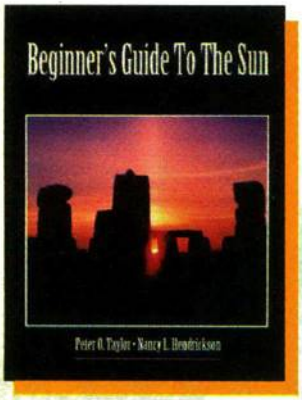
Beginner's Guide To The Sun
Peter O. Taylor · Nancy L. Hendrickson

Beginner's Guide to the Sun
Beginner's Guide to the Sun explains the only safe way to look directly at the Sun. In plain English the authors reveal our closest star's secrets—from its earliest significance to primitive priests and astronomers to the amazing cycles of sunspots, eclipses, and size fluctuations we can observe today. By Peter O. Taylor and Nancy L. Hendrickson. 7⅜ x 9¼; 160 pgs.; 80 b&w and 16 color photos; softcover.
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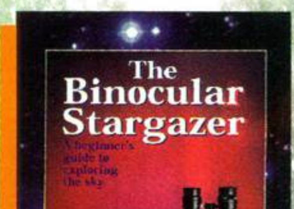

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"and as yet it is not known if this is human or animal-based life." Gone are the days, it would seem, of an informed authoritative nobility, as was transmitted during the Apollo space program, when we were in the wise, paternal hands of the likes of Walter Cronkite. We sensed that he cared about our knowledge, and respected the intellectual curiosity of the listening public.

Dramatic events are perceived as such because they upset a "status quo" within our minds' image of the world, probably at a primordial, tribal level. Cataclysmic events also illustrate, dramatically, the possibility that we can be extinguished by circumstances beyond our control. The perception of this loss of control can be the cause of great concern — it equates with survival. Suggesting even a distant, abstract hint of real evidence for life elsewhere is a foggy, potential detractor from our perception of control over our destiny.

Though many in the clergy seem to be downplaying the significance of this find, time may be more challenging to their tenets. Especially if the "Mars Rock" is determined to contain what its initial researchers claim, and succeeding missions to Mars continue to uncover compelling, even convincing evidence for life. In this case we should expect more headlines to come.

The Mars Rock is touching — if not yet prodding — our casual, status-quo image of ourselves and our world. It may be less than significant if the skeptics are successful in demonstrating chemical work at play. But now there are other distant hints gaining our attention, such as the discovery of more planets orbiting nearby stars and suggestions of icy waters on Europa. The Mars Rock, this little potato-shaped stone, may mature our perceptions — of a universe in which we may be but one tribe of many. ⊏

Claudio Veliz, a New York architect, conducts photoelectric photometry of variable stars, and times lunar and planetary occultations from his Manhattan rooftop.

Astronomy Books for Serious (& Just Curious) Observers

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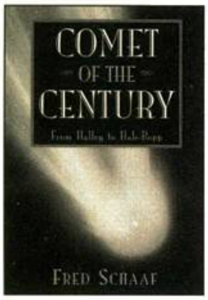
From Halley to Hale-Bopp

FRED SCHAAF



What may prove to be the Comet of the Century, Comet Hale-Bopp, is streaking toward its rendezvous with the Sun and Earth. In this book, whose publication is timed with Hale-Bopp's first naked-eye appearance in the evening sky, the renowned astronomy writer Fred Schaaf offers a delightful history of the greatest comets ever recorded – the astonishing lore and the even more astonishing science – and tips on how you can participate in comet history by catching a glimpse (and maybe quite a bit more than a glimpse) of one of the great comets of the century.

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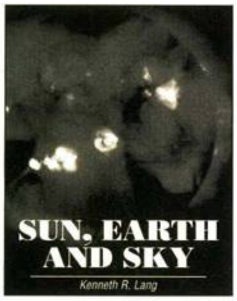
KEN LANG, Tufts University, Meford, MA



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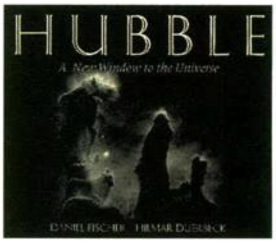

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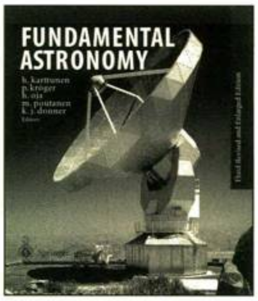
Third Edition

H. KARTUNNEN, P. KRÖGER, H. OJA, and **K.J. DONNER,** all, University of Helsinki, Finland (Eds)



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Hubble Spots Most Distant Galaxies?

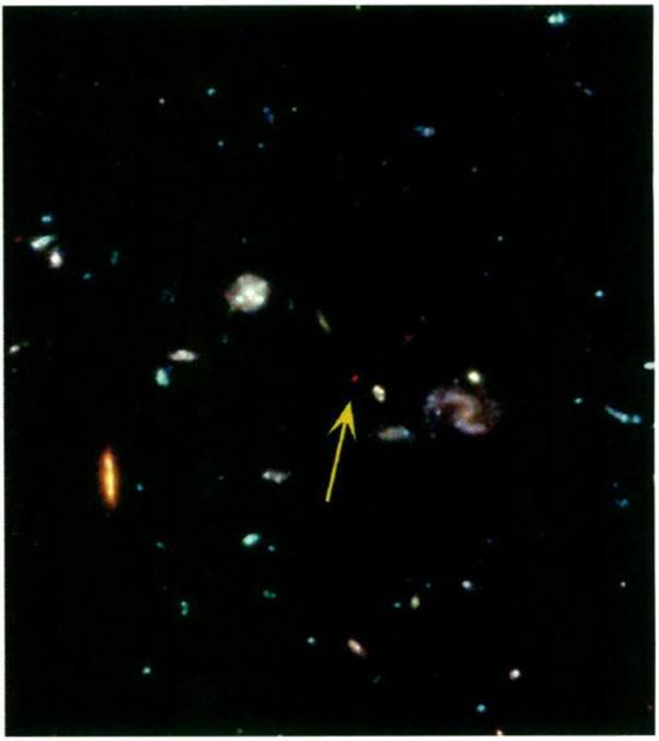
Astronomers examining the Hubble Space Telescope's Deep Field image (see "Approaching the Edge of Space and Time," April 1996) have discovered six faint galaxies that appear so far away that we may be seeing them as they were when the universe was only 5 percent of its present age, a few hundred million years after the Big Bang. If true, these galaxies would be the most distant objects ever observed.

The discoverers, Kenneth Lanzetta and Amos Yahil of the State University of New York at Stony Brook, and Alberto Fernández-Soto of the University of Cantabria in Spain, consider their result to be tentative because they have not yet directly gauged the distance to these galaxies.

Astronomers typically determine the distance to galaxies in the faraway universe by measuring how much the object's spectrum is shifted toward the red due to the universe's expansion. In this case, the six objects are so faint (the brightest is 26th magnitude) that there's not enough light to take a spectrum. So Lanzetta's team indirectly inferred the galaxies' distances by taking closer galaxies and using a computer to redshift them by differing amounts until they matched the Hubble Deep Field galaxies.

Instead of being full-blown galaxies, these six objects appear to be pockets of star formation only 3,000 light-years across. "We may be witnessing the first star formation associated with the initial collapse of galaxies," writes the group in the June 27, 1996, *Nature*.

Perhaps more important than what the group found is what they did not find. They didn't find nearly as many galaxies at extreme distances as many galaxy formation theories predict. Lanzetta's team argues that this lack of distant galaxies implies that the universe is precariously balanced between eternal expansion and eventual collapse.



Ken Lanzetta and Amos Yahil (SUNY at Stony Brook) and NASA

The arrow points to a proto-galaxy that might be the most distant known object in the universe. This image is a tiny portion of the Deep Field image taken by Hubble in late 1995.

Solar System Rock Exchange

Recent computer simulations by a team led by Brett Gladman of Cornell University help improve our understanding of how planets and satellites exchange material with one another. Every now and then an asteroid or comet hits a planet or satellite with enough force to blast debris into space. The simulations show that the fragments, which range in size from specks to football-size rocks, can orbit the Sun for aeons. Gravitational jostles from the planets constantly change the rocks' orbits. Eventually, the interplanetary vagabonds either crash into another planet or satellite, are ejected from the solar system by Jupiter, or hit the Sun.

The simulations show that Moon fragments typically take tens of thousands of years to reach Earth. Martian rocks, however, take millions of years. About 40% of the material blasted off the Moon reaches Earth. Only 4% of martian material makes its way to Earth, although that tiny percentage includes the Allan Hills 84001 meteorite that NASA scientists believe contains evidence of ancient life on the Red Planet (see "Was There Life on Mars?" page 46).

The simulations explain why the same number of martian rocks as lunar rocks have turned up on Earth. Scientists find martian and lunar rocks in the Antarctic ice sheet, which is only about 100,000 years old. Because lunar rocks reach Earth so quickly, scientists only find pieces that were blasted off the Moon in relatively recent impacts. In contrast, martian rocks take much longer to get here, so our planet receives a steady stream of them from much older and larger impacts.

Space Shots of the Aurora

The best images ever made from space of Earth's northern and southern lights were recently released by investigators working with NASA's new Polar Plasma Laboratory (POLAR) satellite, and were presented at the meeting of the American Geophysical Union in Baltimore, Maryland, on May 23, 1996.

"POLAR is crucial to the International Solar Terrestrial Physics Program (ISTP) as it shows the reaction of the upper atmosphere to magnetospheric

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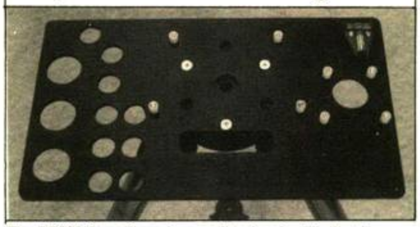

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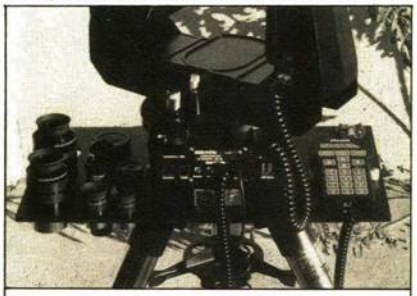

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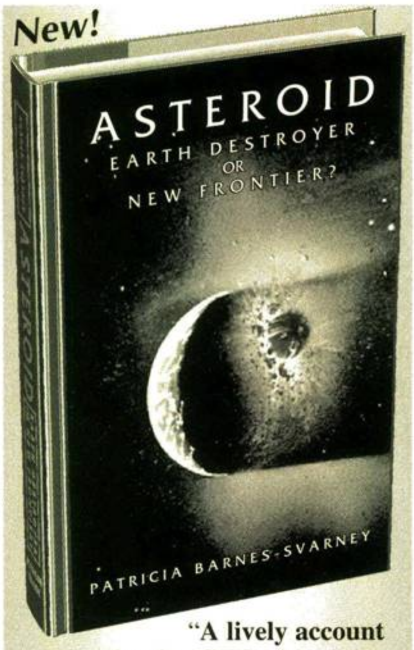

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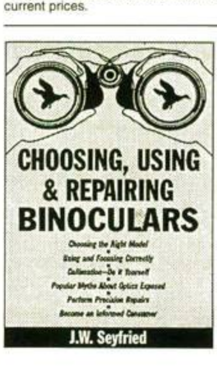
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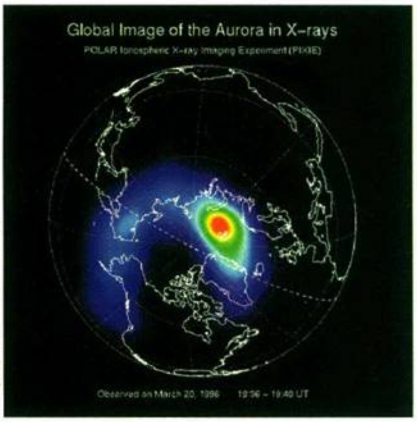
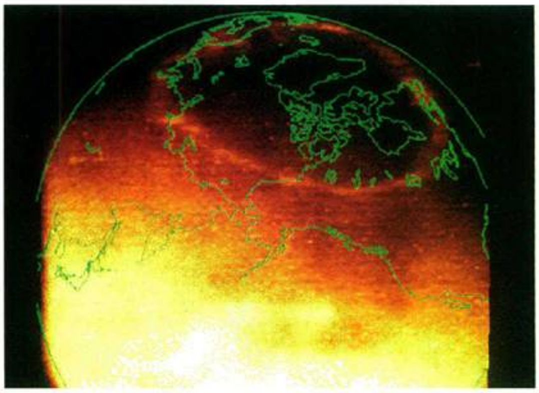

Global Image of the Aurora in X-rays
POLAR Ionospheric X-ray Imaging Experiment (PIXIE)
Observed on March 20, 1996 19:36 – 19:40 UT

David Chenette, POLAR Ionospheric X-ray Imaging Experiment (PIXIE)

The first global image of the aurora in X rays will help scientists better understand the effects of energetic electrons hitting the upper atmosphere of Earth.



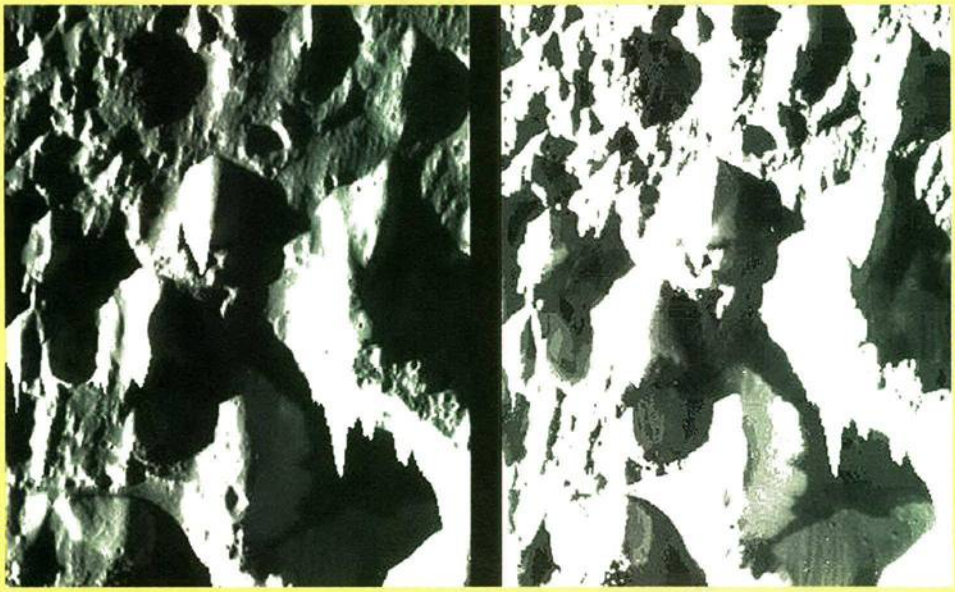
Louis A. Frank and John B. Sigwarth, Earth camera — Visible Imaging System

A full northern auroral oval appears in this spectacular view taken in ultraviolet light. It looks like a "crown" in the top portion of the image. The POLAR satellite imaged Earth from an altitude of 25,740 kilometers (16,160 miles) over the southern coast of Alaska near local noon on March 25, 1996.

disturbances triggered by moving phenomena in the solar wind," said Mario Acuna of the Goddard Space Flight Center in Greenbelt, Maryland.

"The goal of this research is to be able to predict when and where disturbances might occur in the magnetosphere and ionosphere, and how severe they might be," he added. "Electromagnetic disturbances in space have been found to affect a number of complex high technology systems on which society is becoming more dependent."

POLAR joins the previously launched Interplanetary Physics Laboratory (WIND) spacecraft as a principal component of NASA's Global Geospace Science program. This is the first phase of NASA's Solar Connections Program and the United States' primary contribution to the ISTP. The new images and information will help scientists better understand how the solar wind transports energy from the Sun to Earth. The solar wind is a turbulent outflow of charged particles that flows from the Sun's outer atmosphere, or corona, and streams throughout the solar system, past the orbits of all the known planets.



NASA/JPL

Galileo's camera shows details as small as 11 meters across in the ice hills and valleys of Jupiter's moon Ganymede. In the left-hand version, the bright areas are hillsides facing the Sun and the dark areas are shadows. The right-hand version has been processed to bring out details in the shadowed regions.

The Sharpest Visual Images

A team of American astronomers using a technique called interferometry has obtained the highest resolution images ever taken in visible light. The images cleanly resolve the closest pair in the quadruple star system Mizar, the star in the bend of the Big Dipper's handle that lies 80 light-years away. Until now, the binary nature of this pair, which are separated by about two-thirds the Mercury-Sun distance, could only be detected by spectroscopic means.

The angular separation between the two stars varies between 6 milliarcseconds (the width of a dime as seen from about 600 kilometers) and 9 milliarcseconds. The Hubble Space Telescope, which doesn't have to contend with Earth's atmosphere, has a resolution of 40 milliarcseconds, the width of a dime as seen from about 90 km.

A group from Cambridge University recently used interferometry to resolve the two stars in the Capella system (see "Sharper than Hubble," AstroNews, June 1996). But

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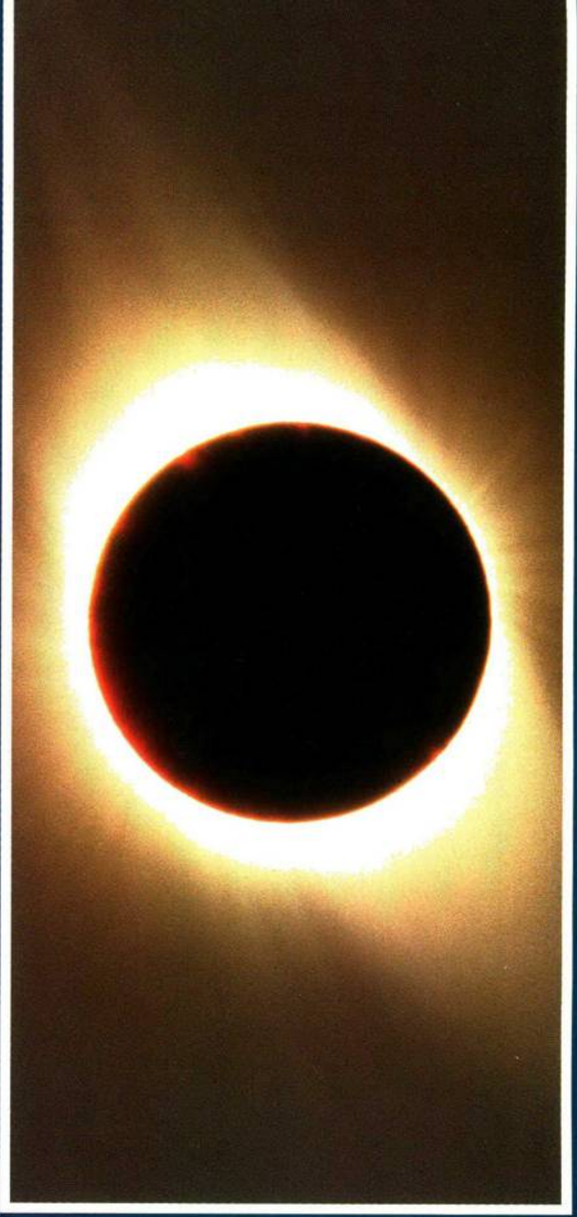

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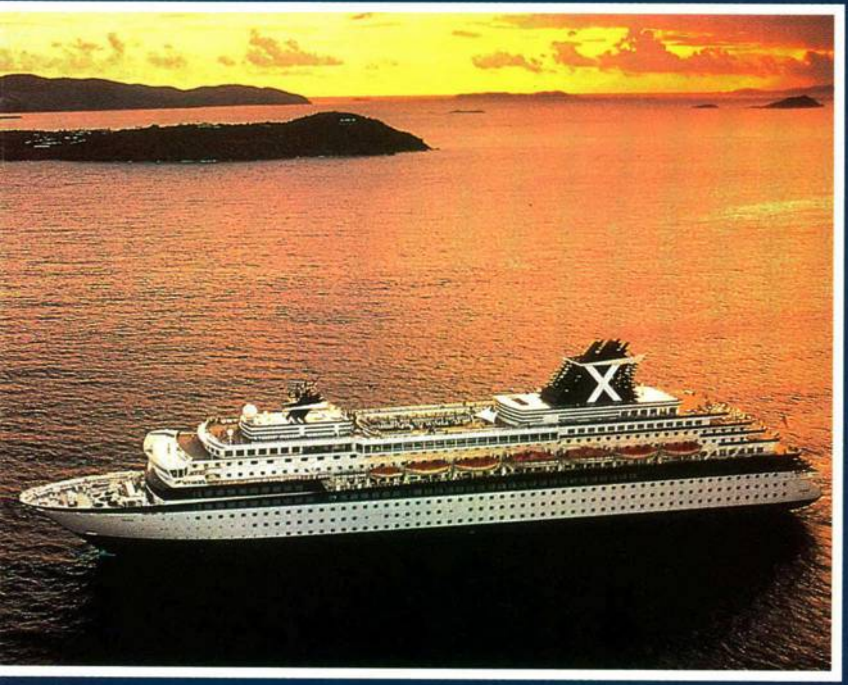

ASTRONOMY editors Dave Eicher and Rich Talcott invite you to daily talks and shipboard constellation watches. Then, on February 26, everyone will view the total solar eclipse through solar-safe filtered telescopes and binoculars. A trip you won't want to miss!

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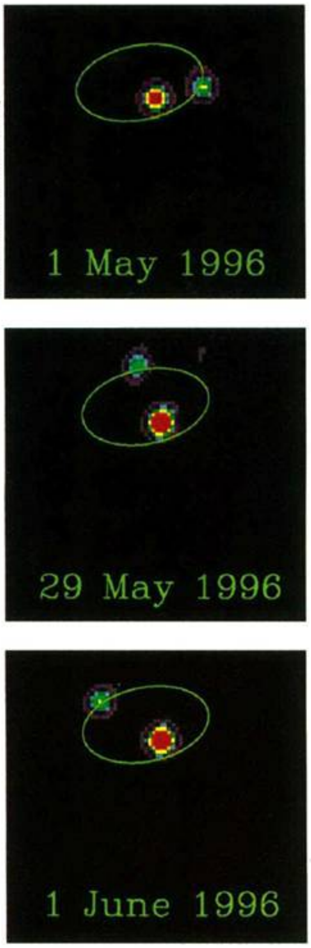
Eclipse photo taken by Ernest Piini.

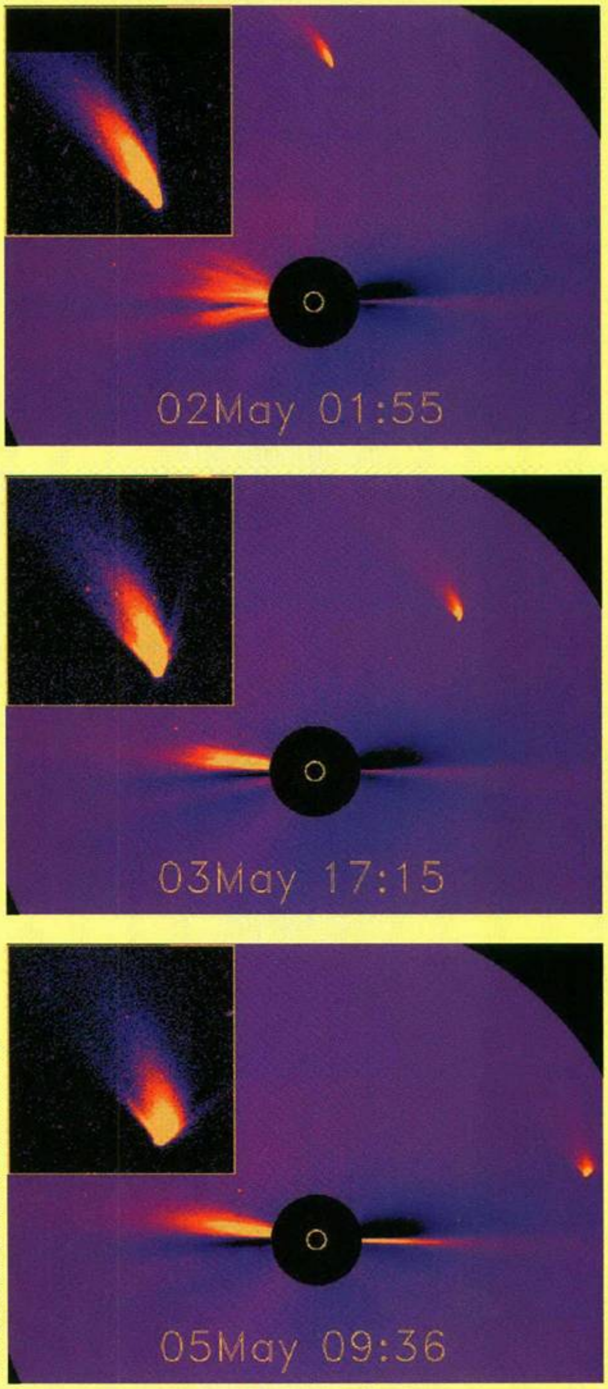


Naval Research Laboratory

The magic of optical interferometry allows astronomers to watch the orbital motion of a binary in the Mizar system.

these new images are at least three times sharper than the Cambridge images.

Interferometry allows astronomers to combine the light from two or more small telescopes to achieve the resolution of a single telescope with an aperture as large as the distance between the small telescopes. The American team, which includes astronomers from the Naval Research Laboratory, the U. S. Naval Observatory, and Lowell Observatory, used three telescopes separated by up to 38 meters to simulate the resolution of a 38-meter telescope. The group plans to add more telescopes to the array and space them over distances up to 437 meters, achieving a resolution of 0.2 milliarcsecond. This will enable the group to image spots and other surface activity on nearby stars.



Michael Andrews (Naval Research Laboratory)

Rounding the Sun

Here we see Comet Hyakutake rounding the Sun between May 2 and May 5, 1996. Astronomers at the Naval Research Laboratory in Washington, D. C., obtained the images from the LASCO instrument on-board the joint ESA/NASA Solar and Heliospheric Observatory (SOHO) satellite. LASCO was designed to observe the solar corona, but scientists took advantage of Hyakutake's passage to make the first observations of a long-period comet making a close encounter with the Sun. "Nobody else could see the comet because it was too close to the Sun," says Michael Andrews of the Naval Research Laboratory. At closest approach on May 1, the comet passed within a mere 32 million kilometers of the Sun, about half Mercury's distance from the Sun.

Besides the comet, these images show considerable activity within the corona. Because LASCO took these images near solar minimum, astronomers had expected the corona to be much more quiescent. The white ring inside the black circle indicates the solar limb. To watch LASCO movies, check out http://lasco-www.nrl.navy.mil/movies.html.

Free-flying Globulars

Well over one hundred globular clusters orbit the Milky Way Galaxy, forever locked in its gravitational embrace. But that number pales in comparison to some supergiant elliptical galaxies, which may contain tens of thousands of globulars. Michael West of Saint Mary's University in Halifax, Nova Scotia, and his colleagues propose that many of these clusters are not bound to specific galaxies, but instead move freely through the cores of galaxy clusters. They report their

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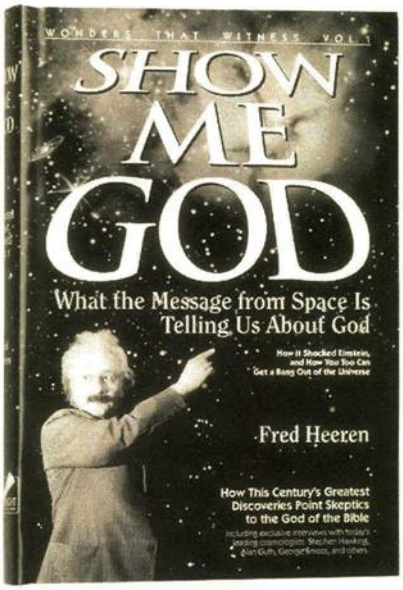
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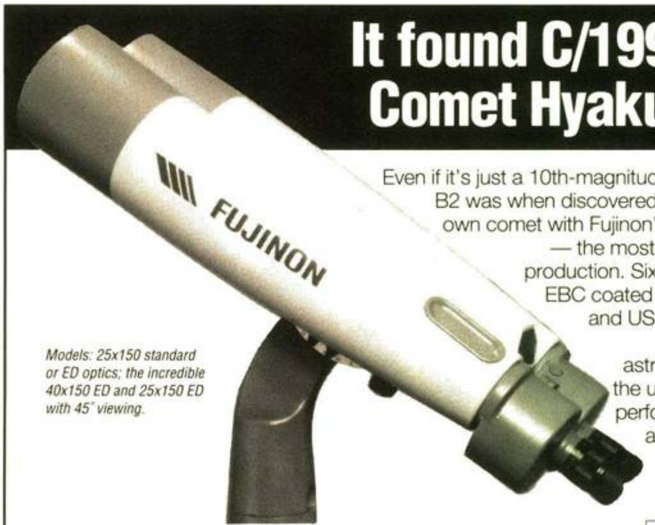
It found C/1996 B2, Comet Hyakutake



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ASTRO NEWS

findings in the November 10, 1995, issue of *The Astrophysical Journal Letters*.

The researchers looked at the brightest galaxies in 12 galaxy clusters. They found that some, such as NGC 5629 in Abell 2666, contained less than 2,000 globulars, a value typical of normal ellipticals in dense environments. At the other extreme are such galaxies as M87 in the Virgo Cluster with 16,000 globulars and UGC 9799 in Abell 2052 with 46,000 globulars.

They suggest that a population of intracluster globulars can explain the differences. In this scenario, all the brightest galaxies are born with about the same number of globulars as seen in typical elliptical galaxies. Added to those are the intracluster globulars, which follow the same distribution as the mass in the galaxy cluster and whose numbers go up with the cluster's mass.

This model accounts for the large excess of globulars seen around massive galaxies lying near the centers of rich galaxy clusters and for the relative paucity of globulars around galaxies that lie in poor clusters or far from a cluster's center. The researchers think these globulars either formed in the intracluster environment or were stripped from other galaxies during collisions and then drawn to the center of the cluster.

AMATEUR NEWS

CCDs at Center Stage

Two hundred CCD imaging enthusiasts of all levels of expertise attended the 1996 Santa Barbara CCD Imaging Conference held July 11–12 in Santa Barbara, California. The conference was sponsored by the Santa Barbara Instrument Group (SBIG), makers of high quality CCD imaging cameras, and Software Bisque, publishers of *TheSky* and *SkyPro* software programs. The organizers' goal was to provide a forum for discussion and for sharing ideas concerning CCD imaging methods, techniques, and instrumentation, and to highlight several practical imaging projects by noted amateur astronomers.

Richard Schwartz, President of SBIG, opened the conference by highlighting the history of his firm. Schwartz noted that development of one of SBIG's most popular cameras, the ST-4, resulted directly from instrumentation he and several partners designed for investigating gamma-ray bursts nearly a decade ago. The company's latest cameras, the ST-7 and ST-8, are sophisticated instruments that each contain two CCD detectors for guiding and imaging.

Steve Bisque, President of Software Bisque, followed Schwartz by showing a time-line of his

EVENT HORIZON

Three Planets Orbiting Lalande 21185?

University of Pittsburgh astronomer George Gatewood reports that a third Jupiter-mass planet might be orbiting the nearby star Lalande 21185 (see "Extrasolar Planet Update," AstroNews, September 1996). The purported planet would orbit the star at a large distance, and would take more than 30 years to complete an orbit. The previously announced planets, both with roughly the mass of Jupiter, have orbital periods of about 6 years and 30 years. If these planets exist, rapidly advancing technology could make it possible to image one or more of them within a year.

A Hubble Milestone

Charles Steidel (Caltech) and NASA

Hubble's 100,000th image shows a distant quasar (the bright object at center), an elliptical galaxy (the faint blob above the quasar), and a foreground star (the bright dot right of center).

On June 22 Hubble took its 100,000th image, a photo of a quasar about 9 billion light-years away. This milestone was achieved about four years sooner than expected because Hubble's observing efficiency has exceeded expectations. Since its deployment in April 1990, Hubble has averaged 1,389 exposures per month. More than 25 percent of Hubble's exposures have been devoted to galaxies and galaxy clusters, and another 25 percent to stars and star clusters. The most popular specific targets, however, have been our neighbors Jupiter and Saturn.

Largest Celestial Catalog

The United States Naval Observatory has compiled a catalog of 491,848,883 stars and galaxies, a list that is 25 times larger than the previous record holder. The catalog contains coordinates for all objects down to about 21st magnitude. The entire database fills 388 CD-ROMs. The catalog will help astronomers point large telescopes more accurately and locate extremely faint objects such as asteroids and distant galaxies.

Motor Planet

Scientists at Columbia University's Lamont-Doherty Earth Observatory have used seismic data to confirm that Earth's solid inner core of iron spins slightly faster than the rest of the planet — fast enough to make an additional rotation with respect to Earth's surface every 400 years. The scientists hope the discovery will advance understanding of the evolution of Earth's interior, how heat flows through the planet, and the origin and behavior of Earth's magnetic field.

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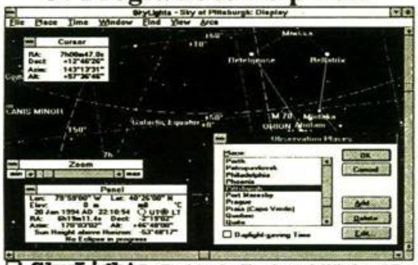

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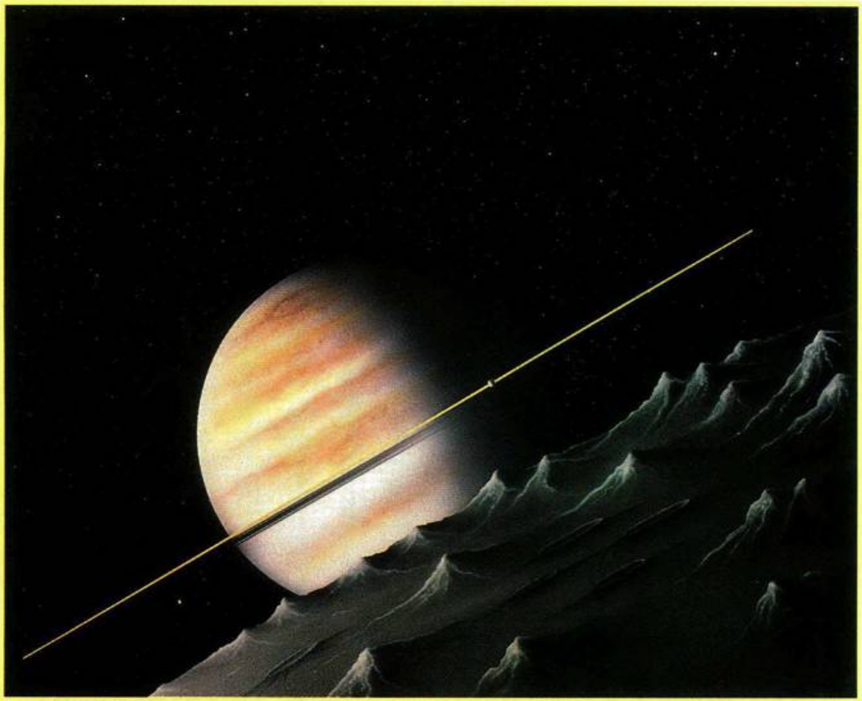

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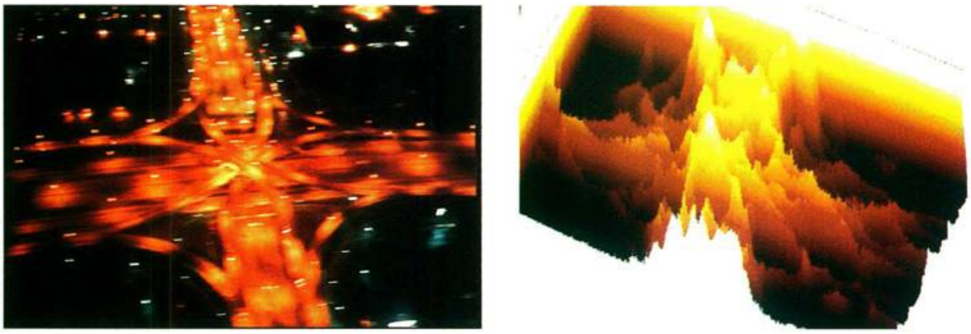

Ardis Maciolek

A highway's contribution to urban light pollution gets laid bare in this analysis done by high school students in Michigan. This and other aerial photos of metropolitan Detroit get filtered through a program that graphically highlights problem areas (right).

company's releases dating from 1984. That year, the company released *TheSky* for DOS , which accurately mapped the positions of 200 celestial objects. *TheSky 4.0* for Windows 95 on CD-ROM, a true 32-bit application released earlier this year, now maps 19 million objects.

Other programs the first day included Alan Holmes of SBIG, who reviewed the basic tricks of the trade involved in CCD imaging at the telescope. His talk covered suggestions for camera set-up and attachment to a telescope, how to find and focus telescopic objects, camera cooling, making flat field and dark frame image corrections, image capture, guiding, color imaging, and final processing of images. He later conducted a program for the audience on the operation of the ST-4 as an autoguider for conventional astrophotography.

The talks on Friday centered around practical applications involving CCD imaging. Glen Gombert showed how he uses an ST-6 to image familiar objects in the near-infrared (see "Beyond the Visible with CCDs," March 1996). Benoit Schillings and Brad Wallis joined forces to discuss a computer program that utilizes adaptive optics and a modified ST-7 auto-guiding camera to improve the resolution of deep-sky objects by a factor of 1.5 to 2. The software will be available commercially through SBIG in early 1997.

Dennis di Cicco of Sky Publishing Corp. talked about basic techniques and his recent success using an ST-6 camera to hunt for asteroids. John Stull of Alfred University in New York informed the group on his students' use of an ST-6 camera to photometrically measure the light curves of cataclysmic binary stars. Tony Hallas wrapped up the session by showing how he takes fabulous conventional astrophotos using an ST-4 camera to guide a 7-inch Astro-Physics refractor.

The two companies are considering a follow-up conference in 1997, either in Santa Barbara or the Denver, Colorado, area.

Conference on Light Pollution

Comet Hyakutake's soft light competed with light-polluted metro skies as ASTRONOMY teamed up with the Astronomical League and the International Dark-Sky Association (IDA) to sponsor a conference on controlling light pollution.

The one-day meeting in Milwaukee, Wisconsin, attracted 72 amateur astronomers from the United States and Canada eager to hear speakers talk about stray commercial and residential lighting.

Wisconsin State Representative James Baumgart shared his experiences about trying to get a bill through the state assembly that would have set uniform statewide standards on night lighting. Though his 1995 attempt failed to clear a conference committee, he plans to reintroduce it during the 1996–97 legislative session.

"It's up to all of you to network with lighting dealers, developers, and consultants to sell light pollution reduction as energy savings," Baumgart said. "Be familiar with your region's energy and lighting statistics. For example, Wisconsin imports $7 to $8 billion in electrical energy annually. Crafting uniform lighting standards would save business millions of dollars each year," he added.

Such statistics are readily available from regional lighting consultants like Milwaukee's Marty Peck, who mentioned there are well over 2,000 lighting codes throughout the United States alone. "Contractors find it a nightmare to reconcile codes between municipalities. The time's ripe for uniform codes that encourage the wise use of light and energy savings," he said.

Peck cited the Illuminating Engineering Society of North America (120 Wall St., 17th Floor, New York, NY 10005) as a good source for lighting and energy statistics for North America. The IDA (3545 N. Stewart, Tucson, AZ 85716) provides, at cost, slide sets and information sheets on light pollution issues.

On the awareness front, Michigan high school teacher Ardis Maciolek shared what students in her district have been doing to ferret out the sources of light pollution. One ambitious project has them conducting aerial surveys of light pollution hot spots throughout the Detroit metro area.

Students graphically analyze pictures taken at night, looking for significant contributors to urban glow. Other class projects include building custom light pollution reduction filters and monitoring neighborhood sky glow from their backyards and city parks. E-mail Maciolek at amacio@sun.science.wayne.edu for more information about these learning modules.

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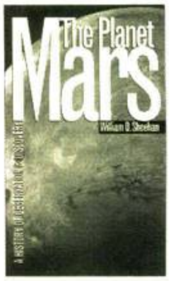

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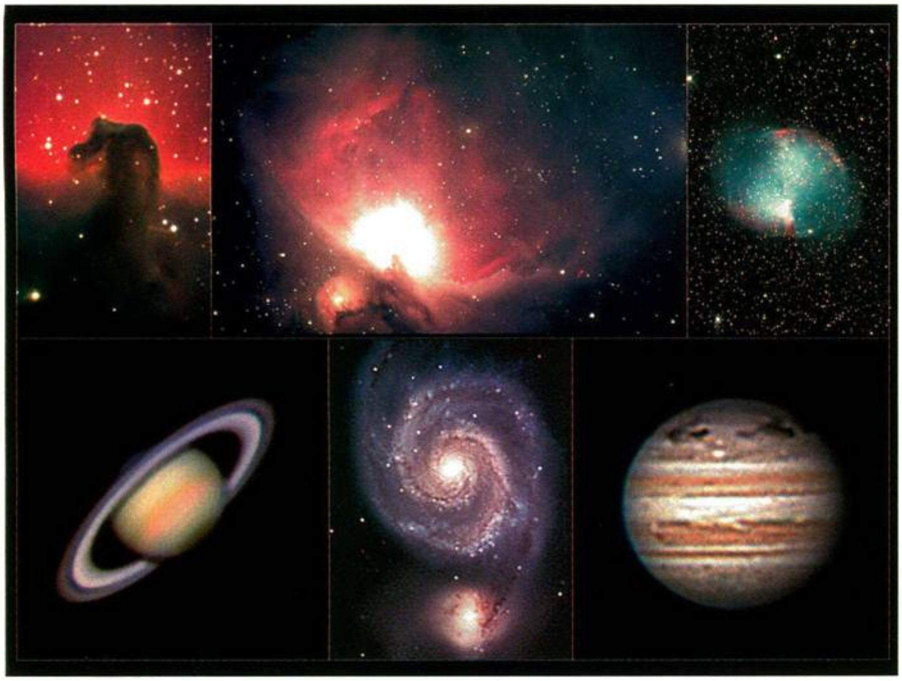

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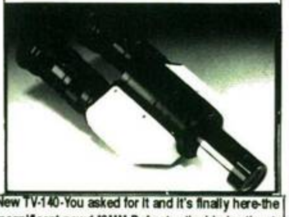

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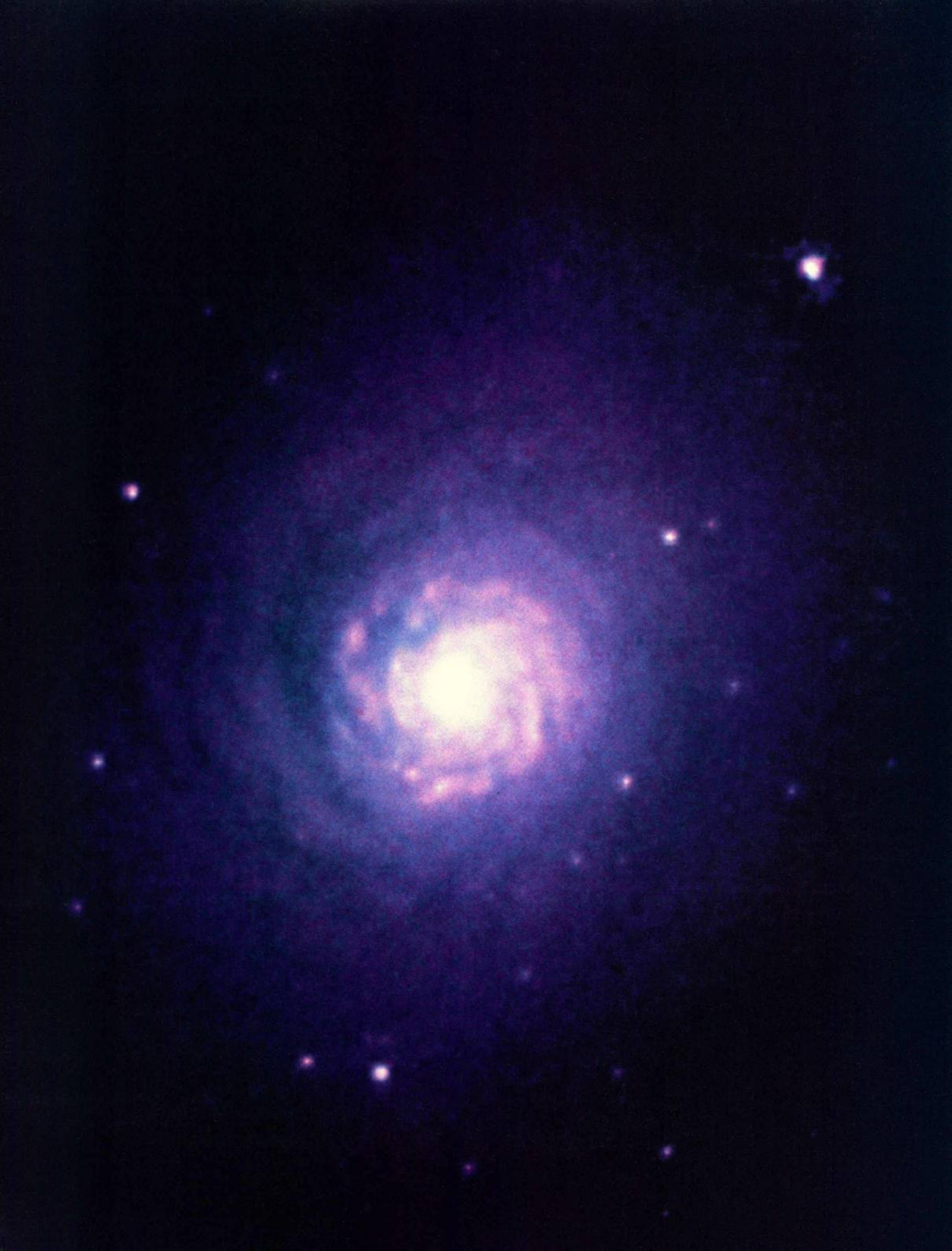


Galaxies *Colliding* in the Night

Violent and commonplace in the depths of the universe, mergers wreak havoc on galaxies and may trigger the births of star clusters and black holes.

by Damond Benningfield

Standing out under the stars and gazing up at the light of the Milky Way, you would never know such violent events are taking place. But they are. Galaxies merge with astonishing regularity, colliding and combining in cataclysmic events that form supergalaxies. Our own Milky Way Galaxy, in fact, is currently digesting a recently discovered dwarf galaxy that lies on the opposite side of the Milky Way's core from Earth. In more massive cases, two or more large galaxies coalesce to form a galactic monster — a giant elliptical that can dominate a cluster of galaxies the way Standard Oil once controlled the oil industry.

"You could hardly find one phenomenon that touches more hot buttons than galaxy mergers," says William Keel, an astronomer at the University of Alabama. "Sometimes it's necessary to pull back on the reins a bit and not blame everything on mergers without enough evidence." Nevertheless, over the last decade or so, increasingly sophisticated computer models, a more thorough understanding of galactic structure and evolution (including the presence of dark matter in vast halos around visible galaxies), and better data from Hubble and other ground- and space-based telescopes have shown that galaxies don't like to leave each other alone.

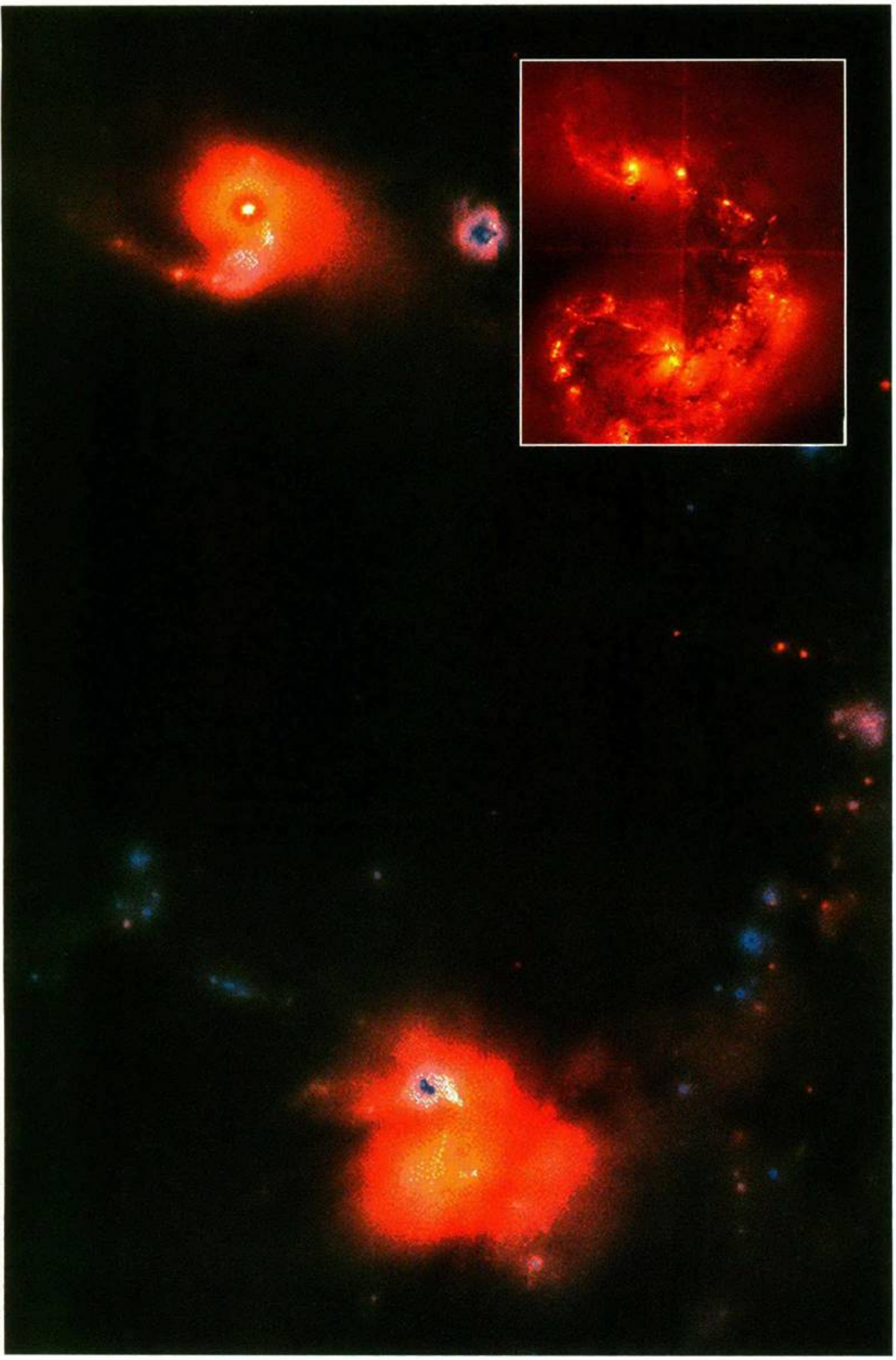
In part, that's because the universe is crowded on galactic scales. The Milky Way's visible disk, for example, spans 100,000 light-years, while the nearest large spiral, the Andromeda Galaxy (M31), lies 2.2 million light-years away. The distance between the two galaxies is only about 20 times their sizes. By contrast, the distance between the Sun and the nearest star is about 30 million times greater than the Sun's diameter. Galaxies are massive objects, too — from a few million to a few trillion times the mass of the Sun — so their gravity is strong. As a result, every galaxy extends gravitational "tentacles" that grab at its galactic neighbors. The tentacles are strong enough to bind large groups of galaxies into clusters.

A spiral or an elliptical? Some galaxy mergers, as with NGC 7252 in Aquarius, show characteristics of both galaxy types. The delicate, tightly wrapped spiral arms of this galaxy appear to surround a brilliant, elliptical-galaxy nucleus. Young globular clusters, triggered by the merger, encircle the arms.

In many cases, though, the influence is even stronger: Galaxies pull on the individual components of galaxies such as stars and clouds of interstellar gas and dust. The resulting interactions can pull streamers of stars out of the galaxies, in some cases forming bridges of stars, and in other cases hurling the stars into intergalactic space. Or they can change the shape of a galaxy. Some astronomers think galactic interactions can trigger spiral-arm formation by creating gravitational "waves" through a galaxy's disk. And there's even some evidence that galactic encounters can create bars in the centers of spiral galaxies.

The Milky Way may be one example. In recent years, some astronomers have suggested that interactions with the Large Magellanic Cloud, a small galaxy that orbits the Milky Way, have created a bar in the heart of our home galaxy. Close encounters with the Large and Small Magellanic Clouds may also have warped the Milky Way's disk. The edge of the Milky Way nearest the clouds curves down a bit, while the opposite edge curves upward. "It's likely that the Magellanic Clouds caused a significant warp," says University of Alabama astronomer Gene Byrd. "At least, the Magellanic Clouds can't be ignored."

Some astronomers think the Milky Way might someday swallow the Magellanic Clouds. In the meantime, it's snacking on another small galaxy discovered in 1994 in Sagittarius. The core of the Sagittarius dwarf lies about 60,000 light-years from the core of



Inset: STScI and NASA

Bradley Whitmore, STScI, and NASA

A galactic hit-and-run resulted when NGC 4038 and NGC 4039 in Corvus slammed into each other several hundred million years ago. Known as the Antennae, the pair unraveled with long ribbons of stars, gas, and dust stretching between the two objects.

Inset: **The explosive chain reaction of star formation in a merged galaxy pair is evident in this portrait of the Antennae. The warped disks of the galaxies are strewn with hot spots where bursts of star formation are occurring.**

the Milky Way — about one-third the distance to the Large Magellanic Cloud. Tidal forces produced by the Milky Way's powerful gravity appear to be ripping the galaxy to shreds, producing large clumps and streamers of stars between the two galaxies.

Such acts of galactic cannibalism — where a large galaxy completely consumes a smaller one — may be fairly common. The Milky Way might have ingested several dwarf galaxies over the eons. According to one controversial proposal, the outer regions of the Milky Way might even consist of the remnants of destroyed dwarfs.

The Andromeda Galaxy might have recently cannibalized a dwarf as well. In 1993, the Hubble Space Telescope found that the galaxy has two dense clusters of stars and gas at its heart, comprising a double nucleus. The second nucleus may be the remnant of a cannibalized dwarf galaxy. But the evidence for a double nucleus is inconclusive. The Hubble images may instead show two parts of a single nucleus with a bisecting lane of dust, giving the nucleus a twin-lobed appearance. New observations that could resolve the issue were acquired last June but have not yet been completely analyzed.

"The merger idea is not one I particularly favor," says Todd Lauer, an astronomer at Kitt Peak National Observatory in Tucson and a member of the Hubble team that studied M31. "It's a lifetime argument. If you set something infalling [into M31's core] it should disappear quickly. This looks very much like it belongs there."

Lauer and colleagues have examined other galaxies that appear to have double nuclei, too. They found that only about 25 percent of these objects are really the result of galactic cannibalism. Many of the rest result from either projection effects, where two objects at different distances appear along the same line of sight, or they are the debris from galactic "collisions" — hit-and-run accidents where one galaxy passes rapidly through another without merging.

One striking example of such a collision is the Cartwheel Galaxy, which lies about 500 million light-years away in the constellation Sculptor. The Cartwheel looks like a giant blue Hula Hoop with a yellow bullseye at its center. Millions of years ago, a fast-moving interloper smashed through the larger galaxy, creating a powerful wave that has traveled outward from the collision site. The wave, which now extends 75,000 light-years from the Cartwheel's center, triggers violent outbursts of new star formation.

By far the most impressive form of interaction, though, is the merger of two large galactic equals — particularly two spirals. They dance a celestial ballet that can last a few hundred million to a billion years or more, eventually losing their own identities as they spiral together to form a giant elliptical galaxy, which looks like a fat football. The newly born elliptical might contain hundreds of billions of stars — and perhaps a supermassive black hole at its heart.

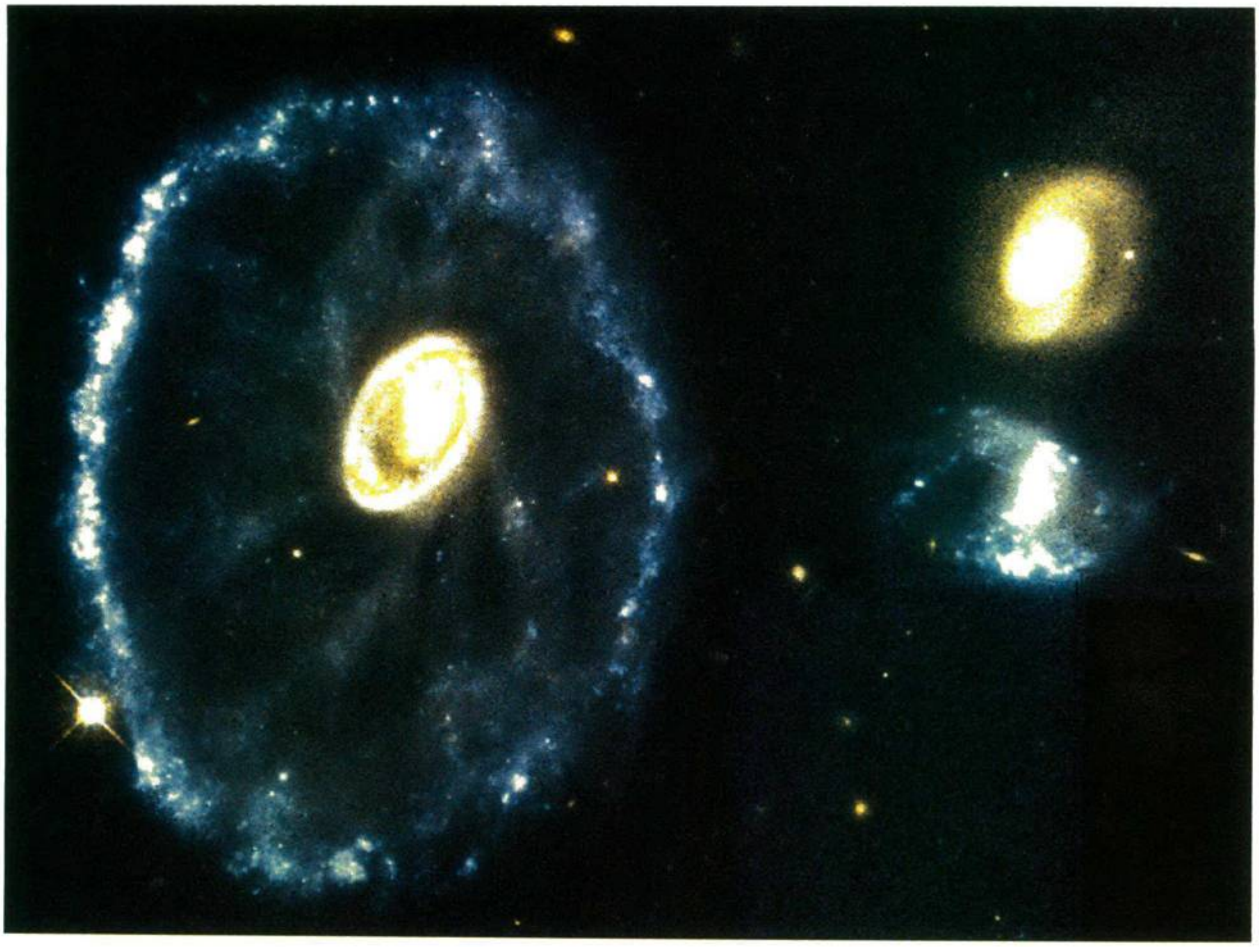
"The idea that you merge two spirals to make a giant elliptical has become more popular during the last 10 to 15 years," says Bradley Whitmore, an astronomer at the Space Telescope Science Institute (STScI) in Baltimore. "Now it's the leading theory." One bit of evidence supporting the theory is the relative abundance of elliptical galaxies in dense clusters, where mergers must be common. For example, ellipticals comprise 85 percent of the bright galaxies in the dense Coma cluster, which lies about 300 million light-years away. Two giant ellipticals at its center dominate the cluster. And the closer Virgo cluster also consists primarily of ellipticals, with three monstrous ellipticals at its heart. Each of the giants spans about two million light-years — 20 times the diameter of the Milky Way. Most spirals, on the other hand, are found in less-dense clusters, where they are less likely to interact with other members of the cluster.

There is other evidence that many large galaxies — including all or at least most ellipticals — formed from two or more mergers. "It fits with the popular concept that in the era of galaxy formation, you start with smaller units and have them clump together," Keel says. "It's seductive to note how the results should be ellipticals. Over the last five to seven billion years, the galactic population has gone from mostly spirals to mostly ellipticals."

"There are a couple of basic theories of galaxy formation," explains Duccio Macchetto, an astronomer at STScI. "One says that you start with the large structure of the universe breaking into smaller and smaller pieces. The other theory — the 'bottom-up theory' — starts with small condensations only a fraction of the size of a galaxy. These pieces merge to form larger pieces, up to the sizes of the galaxies we see today.

"We can't discard either mechanism, but observations favor the second approach. When you look very far away — to redshifts of 3.4, which corresponds to

A high-speed interloping galaxy punched a gaping hole through the Cartwheel Galaxy in Sculptor (left). The direct hit produced a wave of star formation that resulted in the blue ring of infant stars, which spans 170,000 light-years.



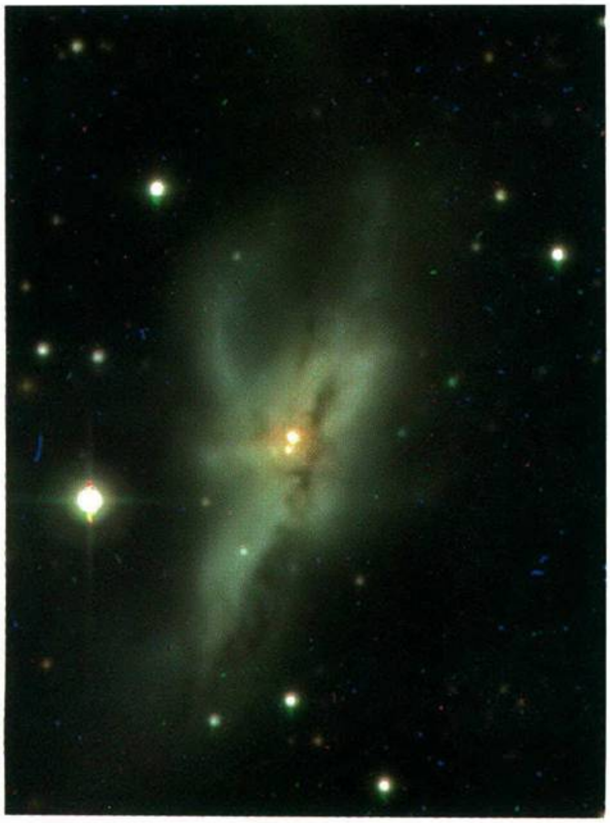
Kirk Borne, STScI, and NASA

an age of just a couple of billion years after the universe formed — galaxies are only a fraction of the size of galaxies today," he adds. "There are some full-sized galaxies, but many, many smaller ones that seem to be merging, that seem to be close together, with some interaction taking place."

Hubble images also show some fully formed ellipticals in the early universe, but many astronomers say that's not a problem. Ellipticals can form from the same accretion process as spirals. And besides, even as early as two billion years after the Big Bang, there should have been enough time for some unlucky young spirals to merge to form ellipticals.

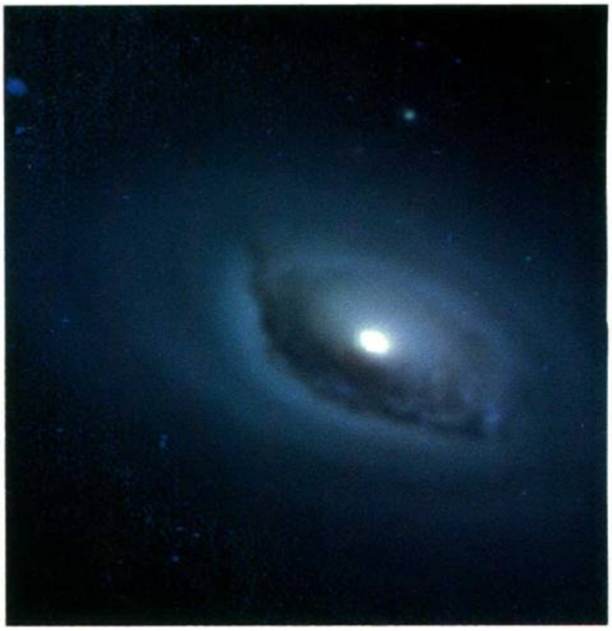
Hubble deep-sky surveys also show many more irregular galaxies — those with no defined shape — in the early universe than are seen in the present-day universe. "A picture is emerging that smaller galaxies must have merged to form the regular spirals and ellipticals we see today," Macchetto adds. "That's a logical conclusion, but it's not yet quantified." Additional Hubble survey images may support the conclusion by targeting high-redshift galaxies discovered by ground-based telescopes. If the images show the same pattern of interacting irregular galaxies, they will support the bottom-up theory of galaxy formation.

The corollary to this theory is that galaxy mergers should be less common now, when there are fewer surviving galaxies separated by more space than in the early universe. Even so, mergers continue today. Astronomers have identified several pairs of large spiral galaxies that are in various stages of merging.



William Keel, Univ. of Alabama

The distorted system NGC 6240 has a double nucleus and tidally warped tails, both signs of a merger. Its reddish central glow results from copious amounts of dust.



William Keel, Univ. of Alabama

The Blackeye Galaxy's distinctive dust cloud resulted from an ancient merger, as did its counter-rotating disks.

Perhaps the most famous example is the pair NGC 4038 and 4039 in Corvus, known as the Antennae. These two spiral galaxies look like interlinked apostrophes, with twin streamers of stars attached to fat, fuzzy blobs of stars and gas. The entire system spans more than 500,000 light-years. As is the case with all such mergers, this one probably began as a gentle flirtation. As the two galaxies passed near each other several hundred million years ago, each one tugged at the other's disk. This tidal interaction, which works like the Moon's tidal effects on Earth, pulled long ribbons of stars, gas, and dust into space. Over time, gravity slowed the galaxies with respect to each other, so they moved closer together and became more tightly locked in each other's embrace. When the disks overlapped, they began to act "sticky," Keel says.

"The orbital energy of the galaxies is transferred to the orbital energy of individual stars, and the galaxies start falling into each other," he says. "After two or three interactions, the nuclei fall together and act like an egg beater, whipping up all the surrounding stars. Once that happens, it only takes about one more orbit to complete the merger."As two spiral galaxies entwine, vast clouds of gas slam into each other. The collision robs them of angular momentum, so they fall toward the center of the merging galaxies, apparently triggering new star formation.

Mergers may be responsible for some "starburst" galaxies, which are undergoing intense bouts of new star formation near their cores. Starburst galaxies often emit most of their energy in the infrared as hot newborn stars warm clouds of dust grains that surround them. And merging galaxies often pass through a phase of high infrared luminosity. One example is the peculiar galaxy Arp 220, which emits more than 95 percent of its energy in the infrared. It may contain a supermassive black hole in its nucleus with several knots of vigorous star formation nearby.

Mergers may also produce new globular star clusters — dense clusters that pack a few hundred thousand to a few million stars into a spherical region of space a few dozen light-years across. Astronomers have discovered more than 700 possible globular clusters in the Antennae, for example — some of them no more than 10 million years old. More than 100 globular clusters orbit the core of the Milky Way, but they contain the oldest stars in the Galaxy.

The Antennae's clusters are much brighter and bluer than the Milky Way's because they contain many hot, blue stars. These energetic stars will die off quickly, though, leaving populations of older, redder stars like those in the Milky Way's globulars. This provides strong support for the notion that giant ellipticals form from the mergers of two spiral galaxies. The relatively large number of globular clusters found in giant ellipticals — more than would be present if you simply add the number of globulars found in two spirals — has been a stumbling block to the merger theory. "A lot of people thought that you should destroy globulars when galaxies merge," says Whitmore. "But a few years ago a small number of researchers, including Francois Schweizer, suggested that maybe a merger creates globular clusters. It sounded like they just made it up."

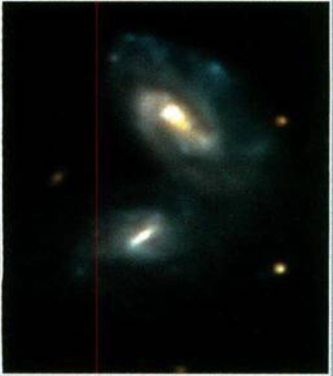
But as the debate progressed, Hubble observations of the peculiar galaxy NGC 1275 in Perseus — the possible remnant of a merger between a giant elliptical and a smaller spiral — revealed abundant young star clusters.

Later, Whitmore and Schweizer found even more possible young globulars in the Antennae and in NGC 7252 in Aquarius, a giant elliptical galaxy with tidal tails that appears to be in the final stages of a merger. Spectral studies with the 200-inch Hale Telescope at Palomar Observatory confirmed that NGC 7252's clusters display the same characteristics as globulars.

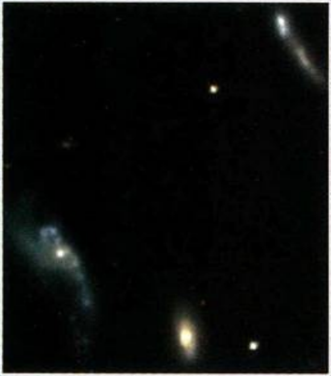
Some astronomers, though, believe that the young clusters are open clusters — loose collections of a few dozen to a few hundred stars, like the Pleiades or Hyades clusters in the Milky Way. In particular, Sidney van den Bergh of the Dominion Astrophysical Observatory in Victoria, British Columbia, argues that

Life inside a merging galaxy could be a hectic proposition, as suggested by this collection of galaxies distorted by interaction and forced union. The chaos resulting from such encounters would unfold over vast amounts of time.

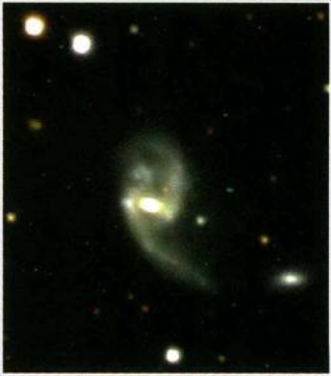
A Rogue's Gallery of Galaxy Mergers



NGC 1738 and NGC 1739



NGC 3991, NGC 3994, NGC 3995



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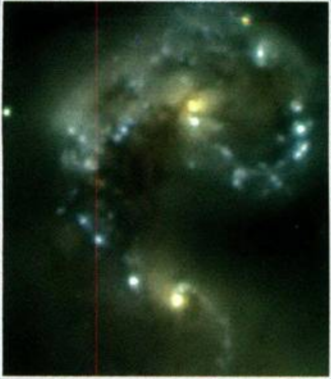
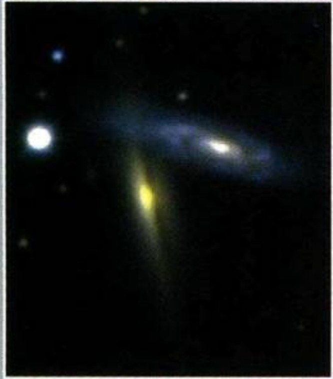
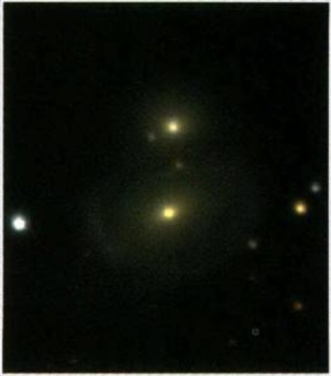


NGC 4038 and NGC 4039



UGC 2942 and UGC 2943



Arp-Madore 0500–620

William Keel, Univ. of Alabama (all)

the luminosity function of the observed clusters — that is, the number of clusters seen at difference brightness levels — closely matches that of the Milky Way's open clusters.

Whitmore concedes the point, but notes that several possible reasons may explain why the HST observations did not reveal smaller, fainter globulars. "Small, diffuse clusters don't have much mass, so they might evaporate," he says. "Or they might be torn apart by tidal shears. Or maybe we just weren't able to see fainter ones with the telescope. This is still in our ballpark. We need to prove quantitatively that this works. The rough numbers seem to be right, but new observations will be the key." HST observations of NGC 7252 also reveal a small spiral structure at the galaxy's heart, like a miniature spiral galaxy wrapped up inside an elliptical. The disk is about 10,000 light-years across — about five percent of the diameter of the entire visible galaxy.

"The fact that there might be a disk in the center wasn't surprising, but such a nice spiral structure was very surprising," says Whitmore. "When I first saw the disk, my reaction was 'Oh my gosh, I gave them the wrong coordinates!' I thought it was the wrong galaxy . . . But about one-third of all elliptical galaxies seem to have this. When you have a lot of gas in a young system, which is what you get with a merger or a smaller cannibalism, you should see a disk." The observation agrees with simulations by Lars Hernquist of the University of California at Santa Cruz and others, which indicate that a central disk is one likely outcome of a merger of two gas-rich spiral galaxies.

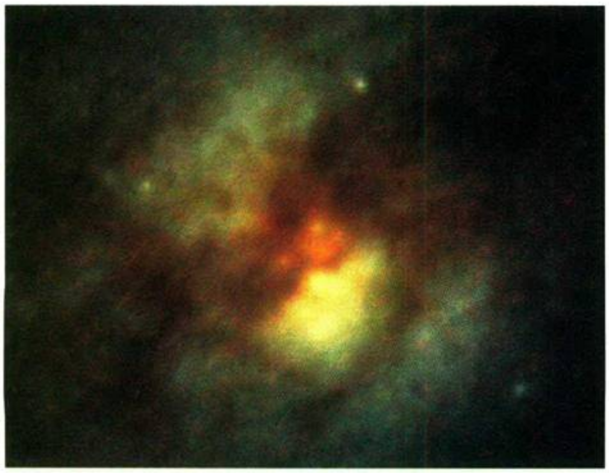
Astronomers have observed similar structure in the Blackeye Galaxy (M64). In this case, though, the galaxy contains two counter-rotating disks — the likely result of a merger between two spiral galaxies that rotated in opposite directions. Radio observations with the Westerbork Synthesis Radio Telescope in the Netherlands detected one gas-rich disk that extends about 3,000 light-years from the galaxy's center, and a second extending from 3,000 to 40,000 light-years. The disks are rubbing against each other at speeds of about 300 kilometers per second, setting off vigorous bursts of star formation.

Friction between the two disks also causes gas to fall into the nucleus, where it may fuel the formation of a central black hole. Or if one already exists, the new gas could reinvigorate its accretion disk, triggering outbursts of X rays. And if two galaxies with black holes at their cores merge, the black holes themselves will also merge, says Andrew Wilson, professor of astronomy at the University of Maryland, perhaps creating the engines that power some particularly energetic "active" galaxies. "Our assertion is that all radio-loud galaxies are produced this way," says Wilson. "Radio galaxies are only associated with ellipticals, not spirals. That was never explained before. But it stands out in the data like a sore thumb."

Wilson says that as two spiral galaxies merge, their central black holes spiral together as well, eventually forming a rapidly orbiting binary system. As they move even closer, their mutual gravity inevitably pulls them together, and they merge in a powerful burst of gravitational radiation. If the original black holes were of roughly equal mass, they should form a rapidly spinning black hole surrounded by an accretion disk.

In the case of the most powerful radio galaxies, the original black holes were perhaps 100 million to one billion times as massive as the Sun, yielding truly monstrous central black holes. In "radio-loud" galaxies, strong magnetic fields funnel electrons into jets that squirt away from the black hole's poles at almost the speed of light. These powerful jets emit radio energy, particularly when they plunge into slower gas

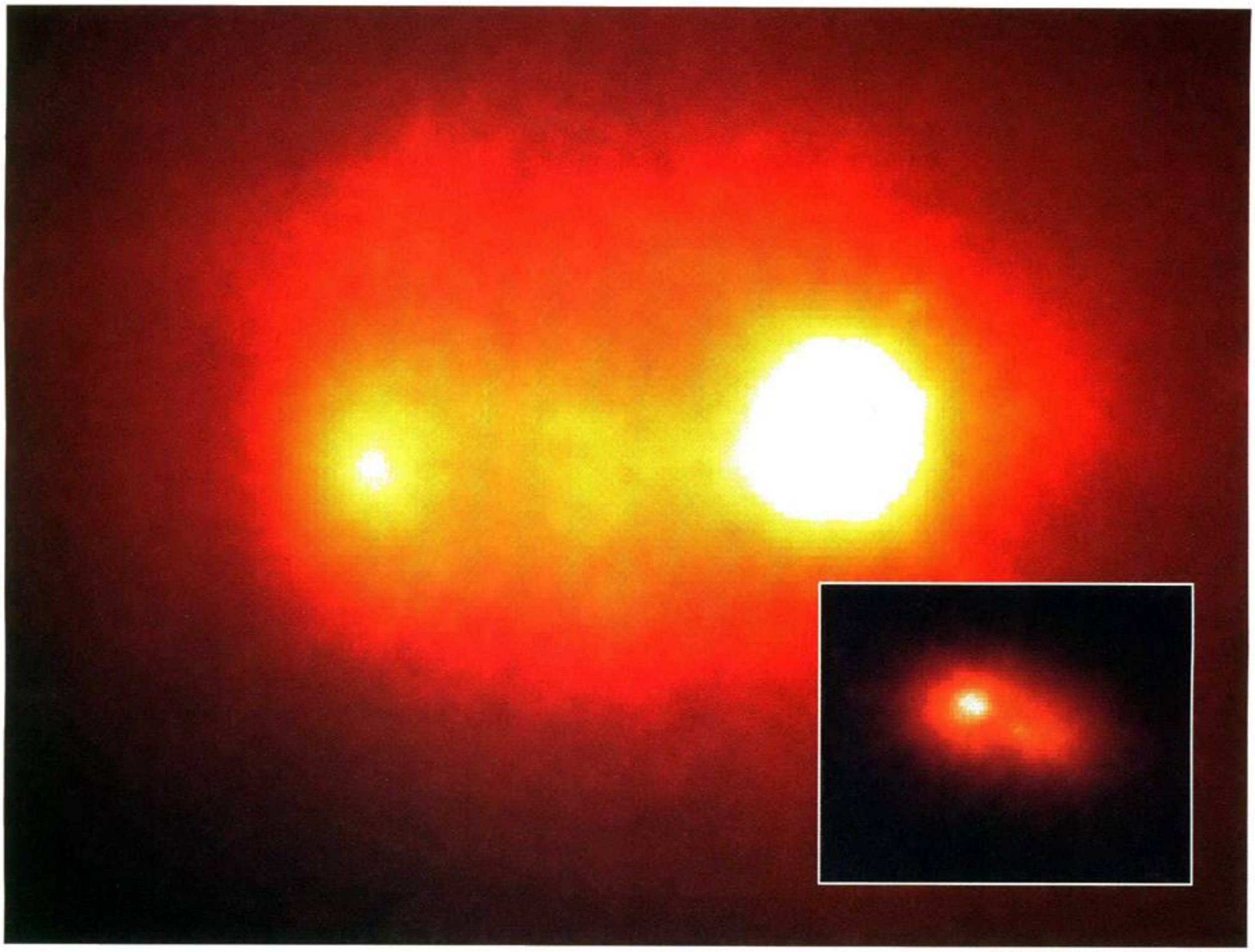
Mergers may trigger not only star formation and supernova explosions but also supermassive black holes. The extraordinarily energetic galaxy Arp 220, the result of a merger, harbors a huge black hole within the depths of its nucleus, surrounded by a thick blanket of dust. The resulting maelstrom would scatter debris for thousands of light-years.



E. Shaya, D. Dowling, Univ. of Maryland, and NASA

Clouds of young globular star clusters, visible as bluish specks, orbit the peculiar and probably merged galaxy NGC 1275. Galactic mergers may unleash a wave of globular cluster production, as evidenced by the youth of these clusters relative to the parent galaxy's much longer history. Such clusters are visible in many other mergers.

Jon Holtzman, NASA



J. Mackenty, STScI, and NASA

Inset: Tod R. Lauer, STScI, and NASA

clouds outside the nucleus. The central black hole acts as a gyroscope, keeping the jets stable over hundreds of millions of years.

Supermassive black holes might also power quasars, the most energetic objects in the universe. Recent HST observations indicate that quasars, too, are associated with galaxy mergers. John Bahcall, a professor at Princeton University, found that eight of 14 observed quasars are not surrounded by bright galaxies, as expected. Instead, they appear to be "naked" power sources — bright, compact regions with no surrounding stars and gas. But most of these quasars are interacting with nearby normal galaxies, and may soon merge with their neighbors.

With such powerful, large-scale goings on, it is tempting to think that individual stars would stand little chance of survival in a galactic merger. In fact, though, inhabitants of star systems inside merging galaxies probably wouldn't feel much effect. Stars are so widely spaced that there are probably no stellar collisions during a merger. The only likely effect is a change in orbit. "Stars can go off in any direction," says Keel. "The disk of a spiral galaxy is very 'cold' — the stars are all flying in formation. But during a merger, the stars are scattered in all directions. In an elliptical galaxy, at any one location it's not unusual to find stars going in about all directions equally."

But for a few hundred million years, the skies around a star inside a merging galaxy must present a stunning vista. Unless the star is embedded inside a dust cloud, skywatchers might see great glowing filaments of hot gas, or streamers of stars hurled into intergalactic space. Near the merged nuclei, gigantic clusters of hot stars would fill the sky with perpetual light, and supernovae would pop like strings of Fourth of July firecrackers. And the constellations would change with startling speed. Because stars could move through the sky in almost any direction, star patterns would change perceptibly even over the course of a human lifetime.

Evidence of galactic cannibalism? Double nuclei in Markarian 315 and the Andromeda Galaxy (inset) may be the smoking guns revealing the last vestiges of now devoured galaxies. In both images the brighter nucleus is the galaxy's center; fainter blobs may be the remnants of the cannibalized galaxies.

If human beings survive long enough, we might even experience such an event first-hand. The Andromeda Galaxy and the Milky Way are on a collision course. About five billion years from now, their disks may merge, perhaps forming a new giant elliptical and erasing all traces of our comfortable — if hungry — galactic home. □

Damond Benningfield is executive editor of Star Date *magazine. His last article for* ASTRONOMY *was "The Odd Little Moons of Mars" (December 1993).*

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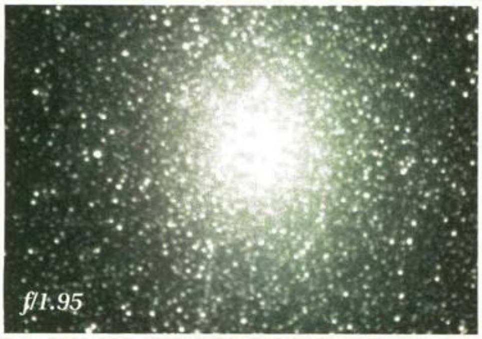
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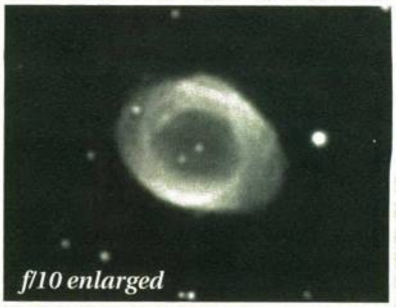
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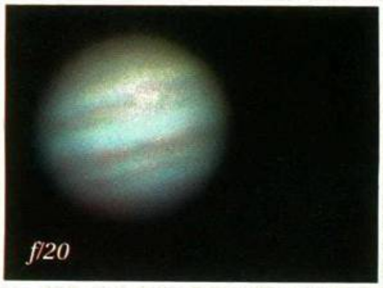
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Was There Life on Mars?

Scientists found signs of ancient Martians inside a meteorite. Did tiny creatures once live there, or are scientists being fooled by Mother Nature?

by Robert Naeye

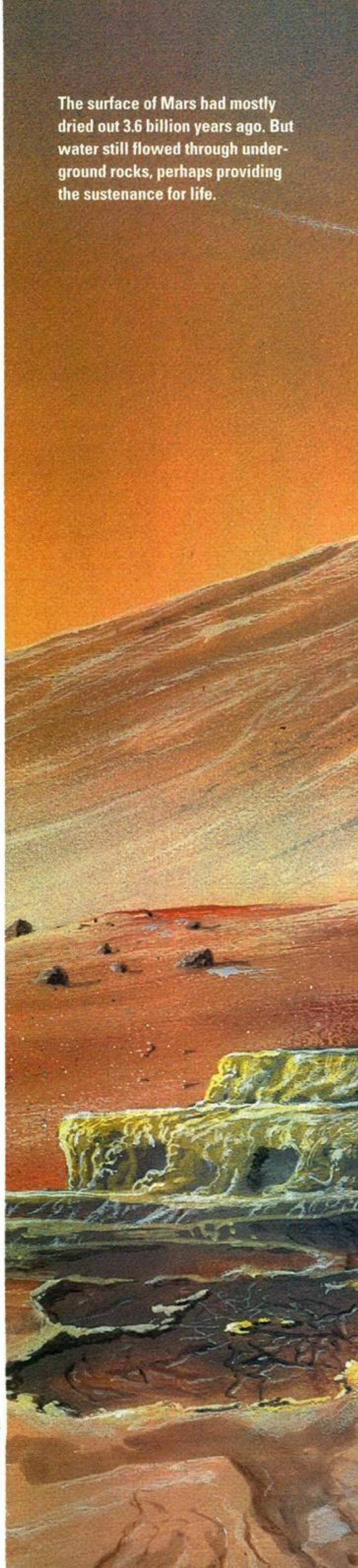
On December 27, 1984, Roberta Score, a member of a National Science Foundation meteorite-hunting team, spotted a potato-size rock in the Allan Hills ice field of Antarctica. From the outset, the rock appeared unusual. "The colors looked different, the rock looked very green. It stood out in my mind that it was kind of weird," she recalls. Little did Score know, or anyone else for the next decade, just how different — and important — this rock was.

A team of scientists announced to the world this past August 7 that nestled deep inside this rock were the first clues that life might have existed somewhere else in the universe besides Earth. The scientists found what appears to be the chemical and fossilized residue of tiny organisms that lived on Mars more than 3½ billion years ago. "There are alternative explanations for each of these lines of evidence that we see," says team leader David McKay of NASA's Johnson Space Center. "But when you look at them collectively, we conclude that this is evidence for early life on Mars."

If life originated on two neighboring planets in the same solar system, it's difficult to escape the conclusion that life is ubiquitous throughout the cosmos. But as soon as the team made their headline-grabbing announcement, critics responded that the evidence was far from conclusive. Just how strong is the evidence that Martians once lived inside this rock?

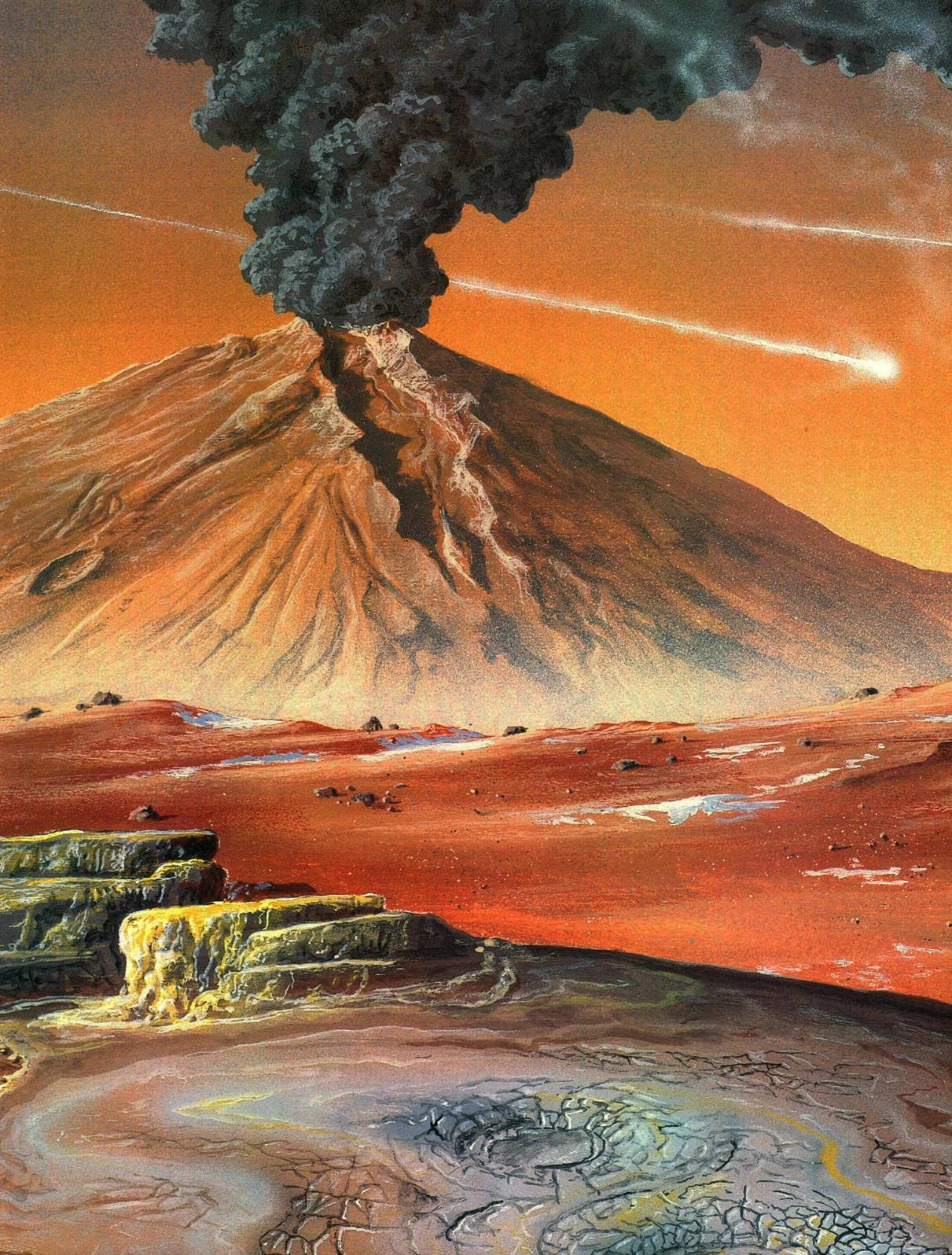
There's a lot of fuss over this potato-size rock! Bacteria-like creatures may have lived inside of it 3.6 billion years ago, when it was on Mars.

NASA/JSC



The surface of Mars had mostly dried out 3.6 billion years ago. But water still flowed through underground rocks, perhaps providing the sustenance for life.

Michael Carroll



Delivering the Evidence

Today, the surface of Mars is colder than a Siberian winter and drier than the driest desert. In 1976 two Viking landers scooped up martian soil and conducted experiments to search for life. The results yielded no conclusive evidence, and most scientists agree that Mars' surface is probably lifeless today (see "Life Elsewhere in the Solar System?" page 52).

But the Viking results certainly do not rule out the existence of life beneath the surface, nor do they rule out the possibility that life flourished in the distant past. High-resolution images of Mars from the twin Viking orbiters clearly show channels and other features that were carved by water about 4 billion years ago. In other words, Mars was once a warmer and wetter place, a place where life could have easily established a foothold (see "Did Mars Once Have Martians?" September 1993). But Mars lost most of its atmosphere soon thereafter and the surface dried up.

Perhaps the most amazing thing is not that life might have existed in Mars' past, but that Mother Nature delivered the evidence right to our doorstep. NASA didn't have to launch a multi-kazillion dollar mission to Mars. Instead, a 4.2-pound (1.9 kg) martian visitor fell to Earth.

An asteroid or comet colliding with Mars at a shallow angle easily can smack Mars with enough force to throw martian rocks into space. Once in space, these chunks of Mars will orbit the Sun in chaotic, eccentric orbits for eons. Recent computer simulations at Cornell University show that about four percent of martian material will eventually fall into Earth's gravitational embrace and crash-land on the planet. Twelve meteorites identified as martian have turned up on Earth, and undoubtedly many more are undiscovered or are sitting around unrecognized in meteorite collections. The martian origin of the possible life-bearing meteorite, which bears the name ALH84001, wasn't even recognized until 1993.

Scientists can identify martian meteorites because the Viking landers sampled the Red Planet's atmosphere. When impacts launch martian rocks into space, the intense heat melts part of a rock, creating bubbles that trap martian air as the rock leaves the planet. The trapped air in each of the 12 known martian meteorites, collectively known as SNCs (pronounced "snicks"), has exactly the same ratio of rare gases as the martian atmosphere (see "Messengers from Mars," August 1995). Because of this and other characteristics shared by the 12 known SNCs, even the staunchest critics of the life interpretation agree that this meteorite probably did come from Mars.

ALH84001 is three times older than the next oldest SNC. It crystallized from molten rock about one kilometer beneath the surface some 4.5 billion years ago, at a time when Mars and the other planets were forming. Based on how much it was exposed to cosmic rays in space, scientists estimate that it was blasted off Mars about 15 million years ago. Soon after landing in Antarctica, the meteorite sank beneath the ice sheet. Subsurface ice flows delivered it to the surface 13,000 years later, enabling Roberta Score to find it in 1984.

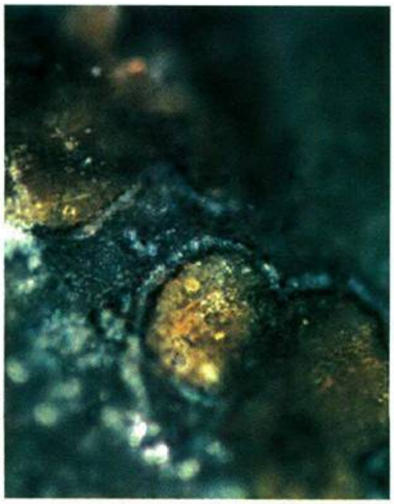
Looking for Life Signs

The meteorite was taken to NASA's Johnson Space Center in Houston, Texas, where it was cleaned and stored with extraordinary care. Once its martian origin was recognized, the rock's great antiquity immediately sparked the interest of scientists.

The meteorite was handed over to David McKay and his team in August 1994. Over the last two years, this group has subjected it to an intense battery of tests using the most sophisticated equipment. The nine-member team, which includes scientists from Johnson Space Center, Stanford University, the University of Georgia, and McGill University in Montreal, cited four distinct pieces of evidence implying that ancient martian organisms once lived inside this rock.

First, they found tiny globules

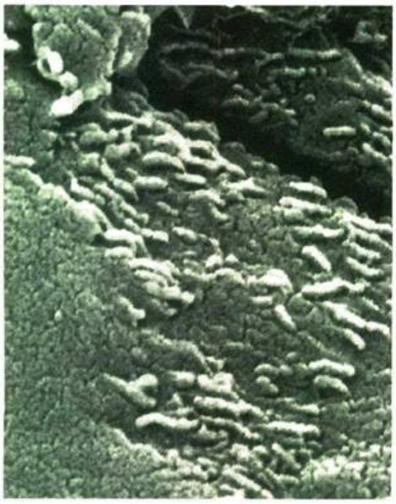
Martian life signs were found in and around the gold carbonate globules.

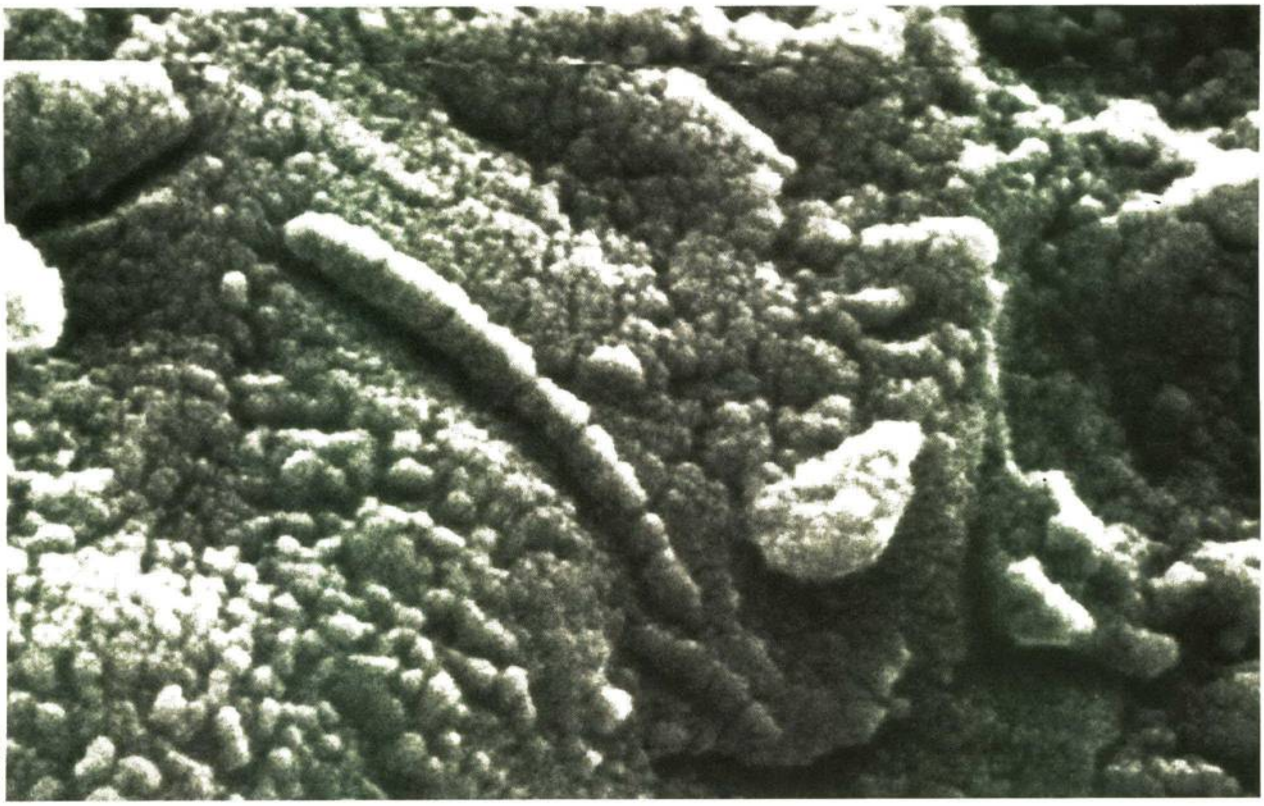


NASA/JSC (all)

A high-power microscope peers deep inside the martian meteorite.

Fossilized remains of a colony? This is a zoom-in from the photo on the left.



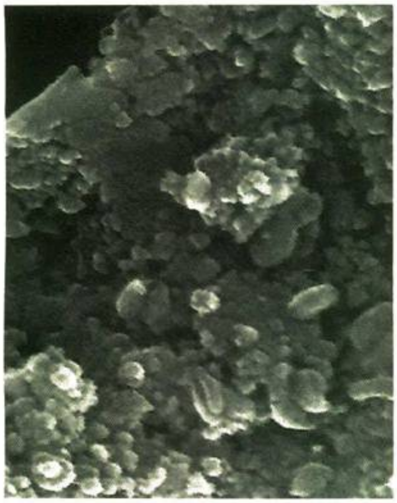


NASA/JSC

This segmented worm-shaped structure might have been a living Martian 3.6 billion years ago. It is about 1/100th the width of a human hair.

of carbonate, a mineral that crystallizes in the presence of water — a key ingredient for life. Three different methods dated the carbonate to 3.6 billion years, strongly suggesting that water was percolating through cracks in the martian crust 3.6 billion years ago even as the surface was drying out. The life signs within the rock presumably date to this same period.

These possible microfossils are 1/100th to 1/1,000th the width of a human hair.



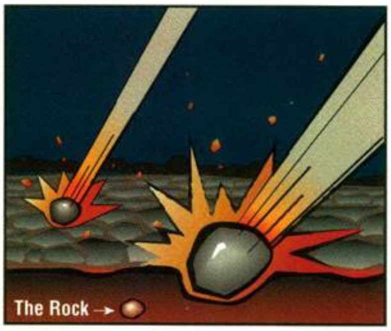
Second, the Stanford contingent on the McKay team, led by Richard Zare, bombarded small pieces of the meteorite with lasers to separate and identify the different chemical compounds in the rock. They discovered organic molecules, the first ever found in a martian rock. Organic molecules are complex, carbon-based compounds — "the stuff of life." All terrestrial life is based on organic molecules.

The specific organic molecules found by Zare's team belong to a class called polycyclic aromatic hydrocarbons, or PAHs for short. These molecules are made up of hydrogen and carbon. They commonly turn up in fossil fuels such as coal and oil. If you've ever burned chicken on a charcoal grill, you've seen PAHs with your own eyes: it's the black gunk on the outside of the chicken. When microbes die, the organic material inside of them often decays into these molecules.

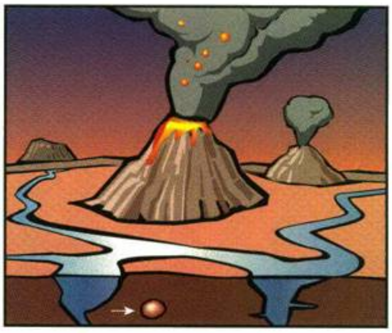
The third key piece of evidence was turned up at Johnson Space Center. A powerful transmission electron microscope revealed tiny minerals inside the carbonate globules that appear to be the residue of biological activity. These "biogenic" minerals are so small that billions could fit on the head of a pin. Just a few years ago, the technology required to see these minuscule structures didn't exist. McKay's team found a mineral made of iron and oxygen, called magnetite, that is produced by terrestrial microbes through their interactions with the surrounding environment. The team also found two minerals made of iron and sulfur, gregite and pyrrhotite, that are common byproducts of terrestrial bacteria and other microbes. This mineral combination is almost never seen inside terrestrial rocks unless life has been there.

Fourth, the Johnson group's powerful microscope took images of tiny tubular and egg-shaped structures. McKay and company interpret these as being the fossilized remains of martian microbes. "This is perhaps the most controversial part of our presentation," admits McKay. These so-called microfossils are so small that one would need to string thousands of them end-to-end to

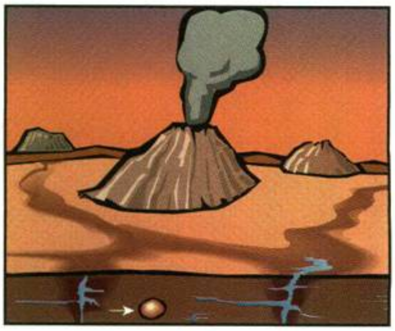
THE STORY OF A MARTIAN ROCK



Mars 4.5 billion years ago



Mars 4.0 billion years ago



Mars 3.6 billion years ago

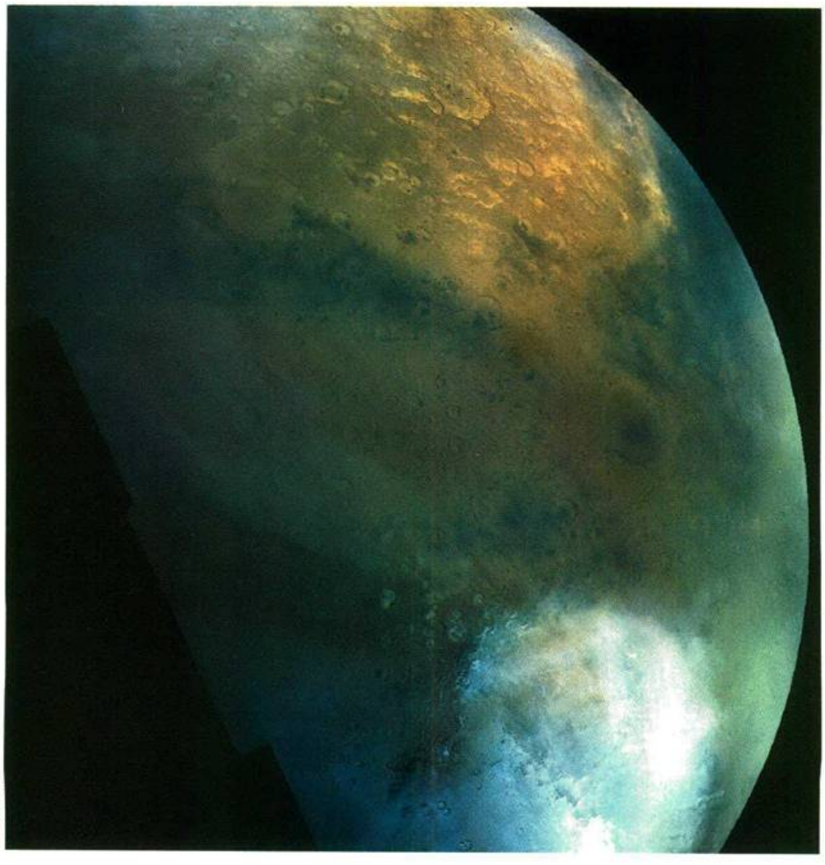
span the period at the end of this sentence. McKay's team points out that these microscopic structures are strikingly similar in size and shape to the tiniest bacteria found on Earth.

McKay's team emphasizes that no single piece of data is conclusive evidence of life. But all of these life signs were found together within a few hundred-thousandths of a centimeter inside the rock, offering compelling evidence that life existed on Mars 3.6 billion years ago.

The Critics Respond

William Schopf of UCLA, who has identified the oldest fossils on Earth, quotes Carl Sagan: "Extraordinary claims require extraordinary evidence." Schopf expresses the caution of other experts in the field when he says, "Personally I think that this is exciting. I think it's very interesting. I think they're pointing in the right direction. But I think a lot more additional work needs to be done before we can have firm confidence that this report is of life on Mars."

For example, ALH84001 has been on Earth for 13,000 years. Are the carbonates, PAHs, and bio-



Mars' polar caps contain water ice, proof that water still exists on the Red Planet today.

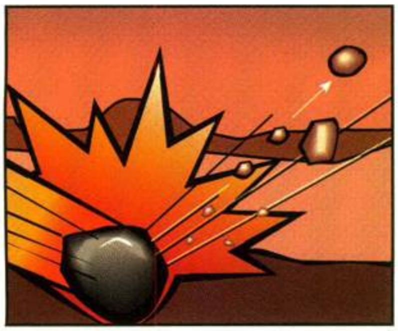
NASA/JPL

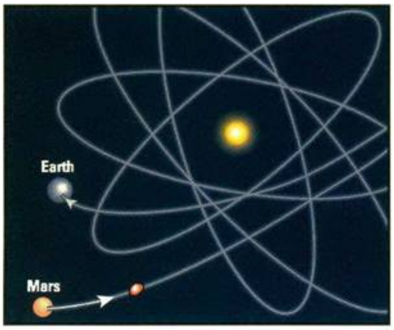
Are *WE* Martians?

If these are martian microbes, they appear remarkably similar to the smallest terrestrial bacteria. "Life needs water, the right mix of organic compounds to run metabolism, and it might need a cellular structure so it can isolate chemical reactions from the broader environment," says Jack Farmer of NASA's Ames Research Center. "Perhaps there aren't a whole lot of shapes that things can take, it may be that at that level things are pretty similar across the board."

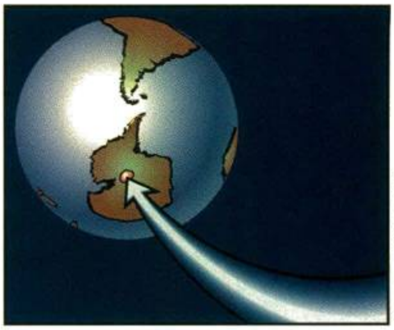
Richard Zare of Stanford, on the other hand, speculates that perhaps *we* are Martians — maybe life originated on Mars and was transported to Earth inside a meteorite billions of years ago. Or perhaps it went the other way. After all, this evidence for martian life dates to the same time life was just getting started on Earth. "It's possible that we were seeded, although there's no evidence that it happened," says Seth Shostak of the SETI Institute. "The rock that's been making all the headlines cruised the solar system for 15 million years. But at least some rocks will take a more direct route, and it only takes one to infect a planet."

It's important to recall, however, that both Earth and Mars had favorable conditions for the emergence of life. For the time being it's much simpler to envision life arising spontaneously on both planets. If biologists can ever get their hands on living martian microbes, genetic tests will likely determine whether or not martian and terrestrial life share a common origin.


Mars 15 million years ago



15 million years in space


Earth 13,000 years ago

ASTRONOMY: Elisabeth Rowan

genic minerals indigenous to the rock, or are they the result of terrestrial contamination? McKay's group has done exhaustive tests to check for this possibility, and its work has satisfied most of the critics. The mixture of PAHs in the rock itself is not at all like the mixture found in Antarctica. The concentration of PAHs increases as one looks deeper into the rock, exactly the opposite of what one would expect from terrestrial contamination. No similar life signs have turned up in other Antarctic meteorites.

The skeptics' chief bone of contention is that all of the pieces of evidence that McKay's team cites — the PAHs, magnetite, gregite, and pyrrhotite — can be easily produced by processes that have nothing to do with life.

For example, star formation produces PAHs. These molecules frequently turn up in other meteorites, and no one attributes their existence to life. So the presence of organic matter doesn't mean that life existed inside this rock. "There's absolutely no way to decide whether these organic compounds are biological or not," says Jack Farmer of NASA's Ames Research Center, who devises strategies to search for ancient martian life.

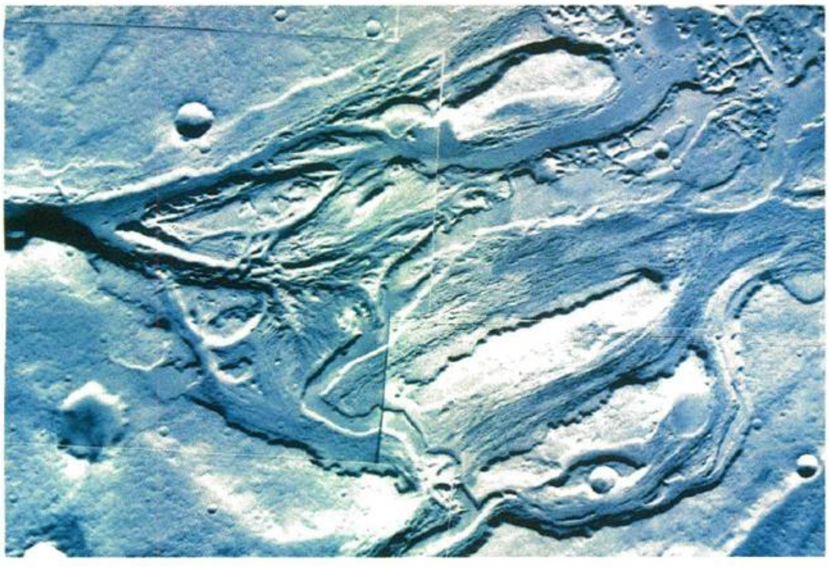
In addition, minerals can crystallize at microscopic scales to produce structures that look exactly like the purported microfossils. "It's impossible to tell the difference without doing more detailed work, which these people have not done," Farmer emphasizes. Moreover, while the tubular and egg-shaped structures in the meteorite look like some of the smallest and most primitive terrestrial bacteria, the oldest fossils ever found on Earth, dating to 3.5 billion years ago, are 100 times larger than these proposed martian fossils.

There's even a question about how the carbonate formed. A month before the McKay team announced its findings, Ralph Harvey of Case Western Reserve University and Harry McSween of the University of Tennessee published a paper in *Nature* arguing that the carbonate formed at a high temperature during a meteor impact about 1 billion years ago, rather than from water percolating through the martian crust 3.6 billion years ago. If their interpretation is correct, the life signs in the meteorite are just an illusion.

On the Other Hand. . .

McKay's team counters that the particular combination of PAHs seen in the meteorite is much more similar to the combination produced by decaying organisms than that originating from non-biological processes. Nor is it like the combination seen in other meteorites.

In addition, the biogenic minerals have almost the exact same size, shape, and composition as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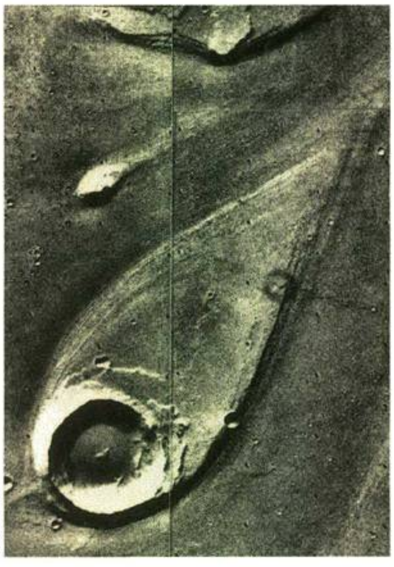

NASA/JPL

Viking photos show the unmistakable signs that liquid water flowed on the surface of Mars 4 billion years ago.

those produced by terrestrial bacteria. Joe Kirschvink of Caltech, who discovered magnetite in living creatures, points out that biologically produced magnetite crystals have different shapes than non-biological magnetite crystals. "It's difficult to produce this shape of magnetite inorganically, yet they're in this meteorite. There's a good chance there was life there, but we need more tests," he says.

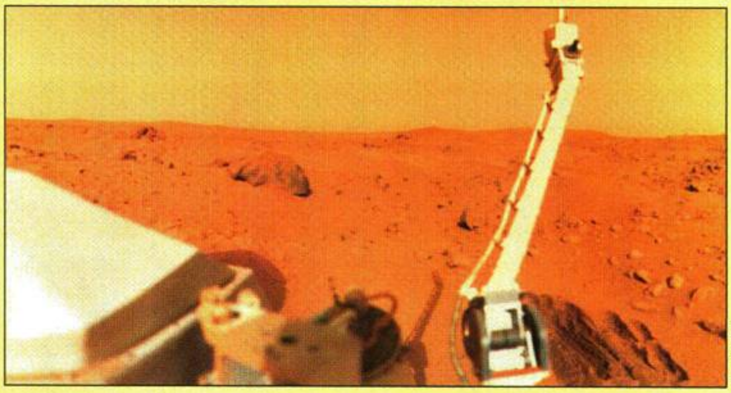
McKay's team also counters that the specific combination of oxygen molecules in the carbonate could not have formed if the temperature was above 80° C, which is consistent with the theory that they formed in the presence of water 3.6 billion years ago.

McKay and his colleagues concede that their interpretation that life existed on Mars 3.6 billion years ago is just that — an interpretation. But they also express great confidence in their conclusion. "What interpretation to place on the data will be decided in the next few years," says team-member Simon Clemett of Stanford. "But if you take all four lines of evidence together, you can explain the observations very easily with a biological origin. You can explain each one independently with an inorganic origin, but you can't explain them all with a single inorganic origin. So there's an easy biological explanation, but there's no easy inorganic explanation."

Onward to Mars

Is there a way to satisfy the critics without mounting an expensive mission to Mars? The answer is yes. The team will perform more tests, cutting the purported microfossils into thin sections to see if their powerful microscope can reveal the actual remains of cell walls and other cellular structures. They will also look for amino acids, the building blocks of life. NASA administrator Daniel Goldin has promised to make samples of the rock available to other researchers, who might, for example, look for evidence of cell division or cellular life cycles. The controversy could be resolved within a year or two.

Life Elsewhere in the Solar System?



NASA/JPL

The Viking 1 lander scooped up martian soil (see trenches in lower right) to search for signs of life.

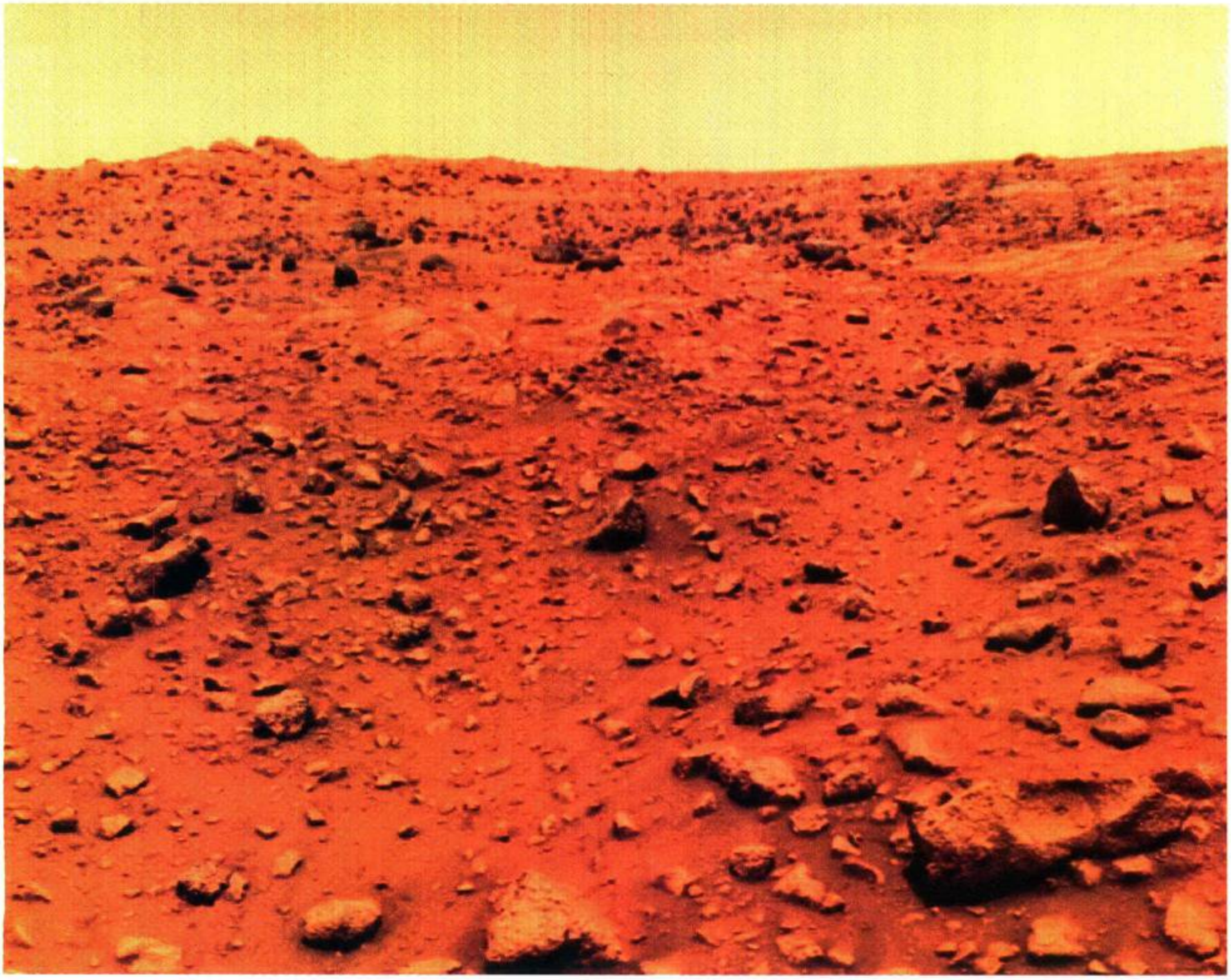
It's not like we haven't been looking for Martians. Twenty years ago the Viking 1 and 2 landers set foot on Mars to look for them. Each craft came outfitted with three on-board experiments to detect telltale signs of life. Another experiment looked for the organic compounds attributable to life. Viking's final prognosis: unusual soil chemistry, but probably no life.

That's no surprise. Mars doesn't have an ozone layer, so deadly solar ultraviolet rays stream down unabated — breaking apart any organic molecules that might form (effectively sterilizing the surface). But David McKay, among others, speculates that martian life could have retreated underground as Mars lost its atmosphere. Evidence suggests that a permafrost layer exists beneath the surface, providing the water necessary for life. For energy, the Martians would likely tap oxidizing agents found in subsurface rocks. Only further exploration can resolve the issue.

But why stop at Mars in our quest for life? Many kilometers beneath Jupiter's cloudtops is a region where temperatures and pressures are very Earthlike. Thanks to the Galileo atmospheric probe's plunge into Jupiter last December, we now know that this 100-km-thick layer has some of the elements needed to support life. Carl Sagan and Arthur C. Clarke have speculated that floating gas-bag creatures might live there. Unfortunately, the probe found little water at this level, which, astronomers feel, may have been an anomalous result in itself.

Two other possible repositories for life are the jovian moons Europa and Ganymede (see "Galileo's Dazzling Flyby," page 56). They could have salt water oceans 60 to 80 kilometers deep beneath their icy crusts. Tantalizingly, the Galileo orbiter's summer flyby picked up a magnetic field at Ganymede, which hints at a subterranean ocean.

Scientists have speculated that one other domain in the solar system might harbor life: Titan, a moon of Saturn. Titan is the only moon in our solar system with a dense atmosphere, one even thicker than Earth's. Titan's atmosphere is also rich in organic molecules. But Titan's surface is a frigid –179° C, which most scientists think is far too cold for life. A visit in 2004 by the Huygens atmospheric probe (which fill fly aboard the Cassini spacecraft) will shed light on what chemistry lies hidden under Titan's cloudy veil. —*John Shibley*



NASA/JPL

The surface of Mars is sterilized by solar ultraviolet radiation. But who knows what lurks underground. . .

Even if it turns out that life did not exist inside this rock, McKay's team has still made an important discovery. "It's just a great find, and a wonderful thing that happened to boost the Mars exploration program," says Farmer. "The data from the meteorite demonstrate that Mars had the basic conditions required for life: liquid water and organics. Furthermore, we had mineralization processes that were able to capture organics and preserve them for billions of years. So these are very positive elements for defining a strategy to go to Mars and look for evidence of ancient life."

NASA is launching two Mars probes in late 1996. The orbiter Surveyor takes off in November and reaches Mars in September 1997. It will image the surface at high resolution. Pathfinder will launch a month later, and will land a cat-sized rover on the surface on July 4, 1997. The rover will explore the surface within a 100-meter radius of the lander. The landing site is at the mouth of an ancient runoff channel, an ideal place to look for life. Unfortunately, the rover is not sophisticated enough to detect life. But it can measure the chemical composition of martian rocks and soil.

Goldin stresses that NASA was planning to launch an armada of 10 low-cost spacecraft to Mars over the next decade, including a possible sample-return mission in 2005. But in the wake of the recent findings, Goldin has promised that NASA will accelerate its Mars exploration program should scientific findings demand it.

Just as evidence turns up for life on ancient Mars, astronomers are finding the first planets orbiting other sunlike stars. These planets undoubtedly represent the tip of the iceberg. An enormous gulf, however, separates intelligent life and the primitive life that might have existed on Mars in the distant past — a gulf that lasted 3.5 billion years on Earth. Whether or not there's intelligent life out there, even the confirmation of primitive life on Mars past or present would mean that in a small way, we are not alone. And as Richard Zare notes, "There are certain defining moments of an age, events that capture uniquely the spirit that changes the course of history. The discovery, if it proves to be such, that we're not alone in the universe would be such a defining moment." □

Robert Naeye (rnaeye@astronomy.com) is an associate editor of ASTRONOMY. *He would like to hear from you via e-mail or regular mail your opinion of the philosophical ramifications of this discovery, and whether you think life has existed on Mars, past or present.*

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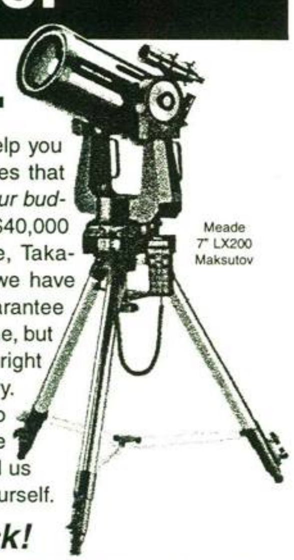

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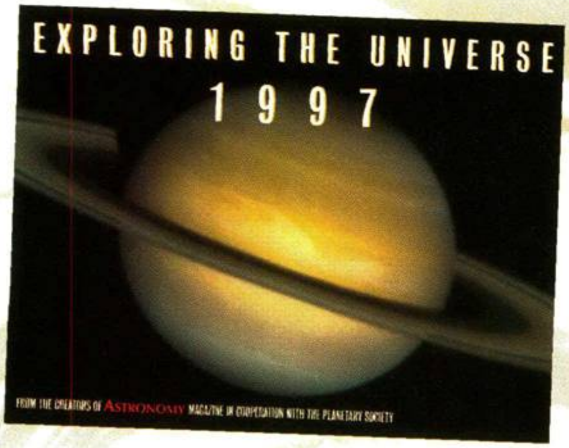
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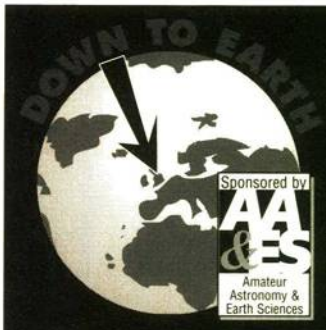

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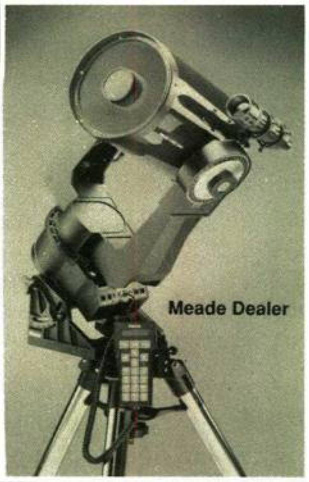

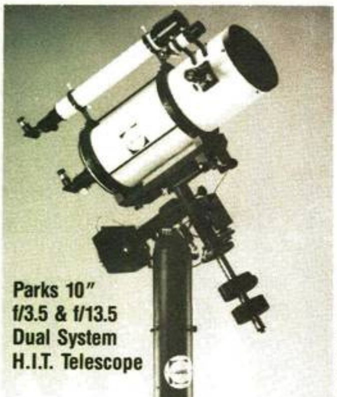

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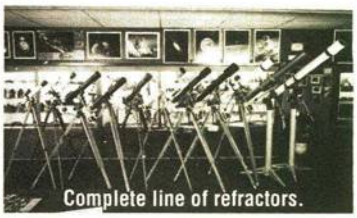

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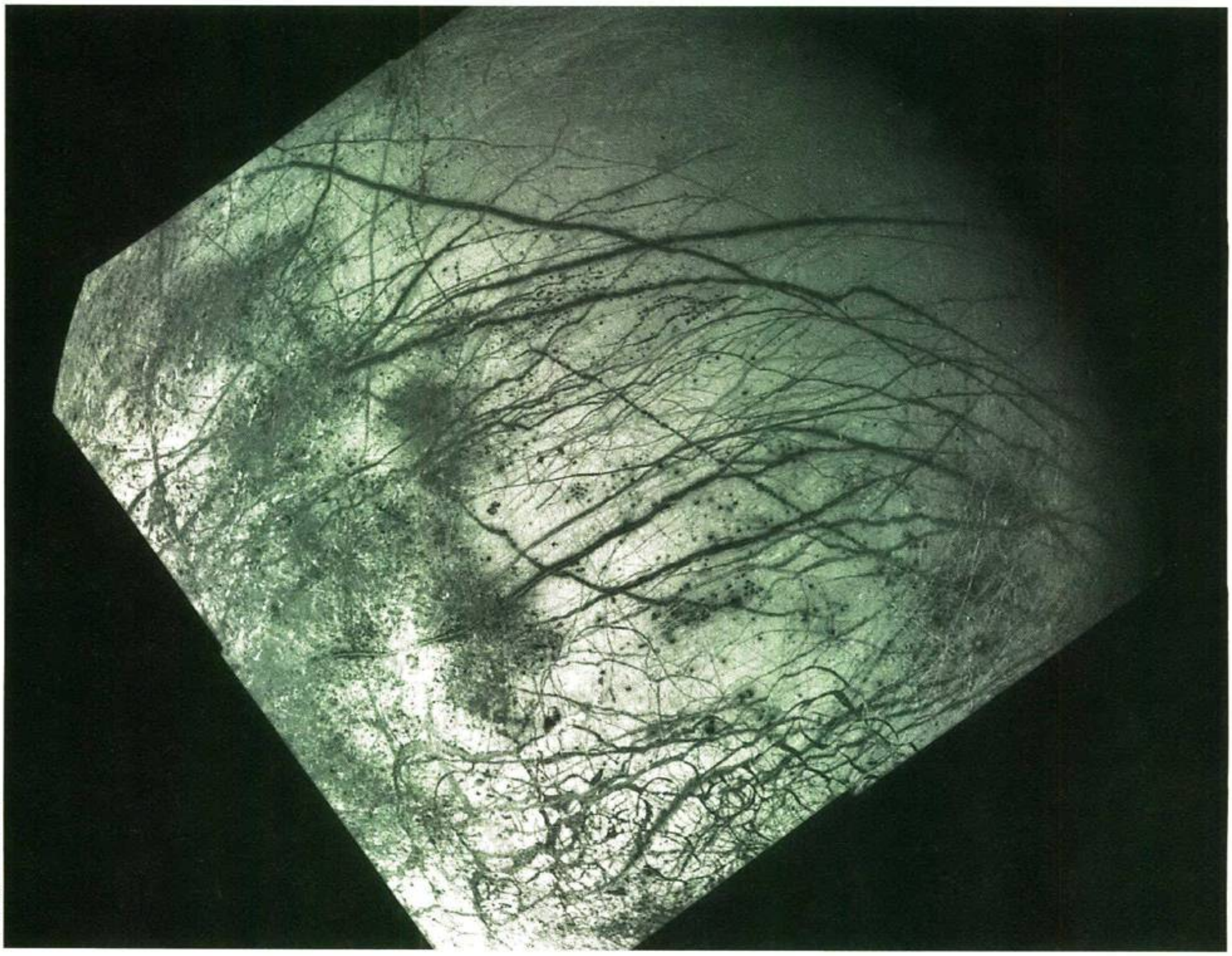
Galileo's Dazzling Flyby

The first close-up images of Jupiter and its moons in 17 years reveal an ocean of slushy ice, massive volcanic eruptions, and towering thunderstorms.

by Richard Talcott



All images: NASA/JPL

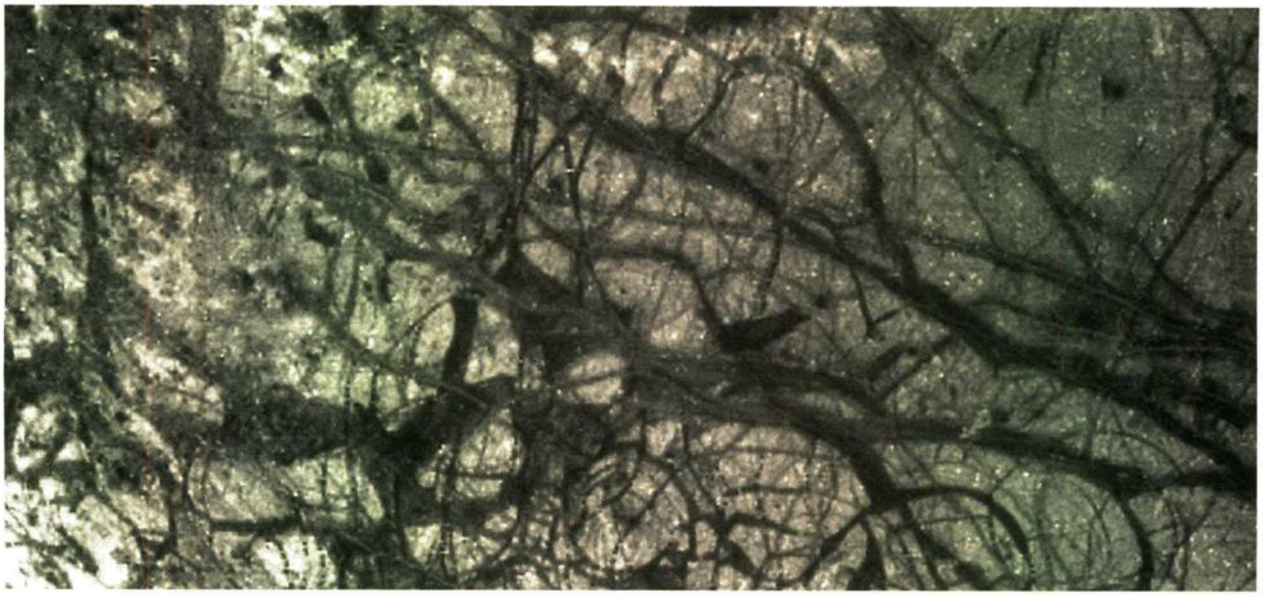
Dark bands crisscross Europa, graphic evidence of widespread fracturing and the possible eruption of gases and rocky debris from the moon's interior. These and other features suggest that soft ice or liquid water existed below the icy crust when the eruptions occurred.

When the Galileo orbiter flew within 855 kilometers of Jupiter's moon Ganymede this past June, it turned an impressive array of instruments toward the largest moon in the solar system. The solid state imaging camera revealed Ganymede's unique grooved terrain in unprecedented clarity, as related in "Galileo's Ganymede Surprise" in the October issue.

That would have been enough, but mission planners had other ideas. They took advantage of Galileo's first excursion into the realm of Jupiter's satellites to also target Io, Europa, and the giant planet itself. The results provide a tantalizing look at these dynamic objects as well as a taste of the more-detailed views coming up later in the mission.

Shortly after passing by Ganymede, Galileo took aim at Europa, the smallest of Jupiter's four large moons and just slightly smaller than Earth's Moon. Europa is covered by a global ocean of water probably 100 km thick, although the top part, at least, is frozen solid. From a distance of 156,000 km (about 25% closer than either Voyager spacecraft came) that yielded a resolution of 1.6 km, Galileo looked upon an area about the size of the United States west of the Mississippi River.

The Galileo images show that some parts of the surface have



Fractures in Europa's surface apparently broke the crust into plates as big as 30 km across. Some of the plates separated and then rotated into new positions, giving an appearance similar to ice floes in Earth's polar seas.

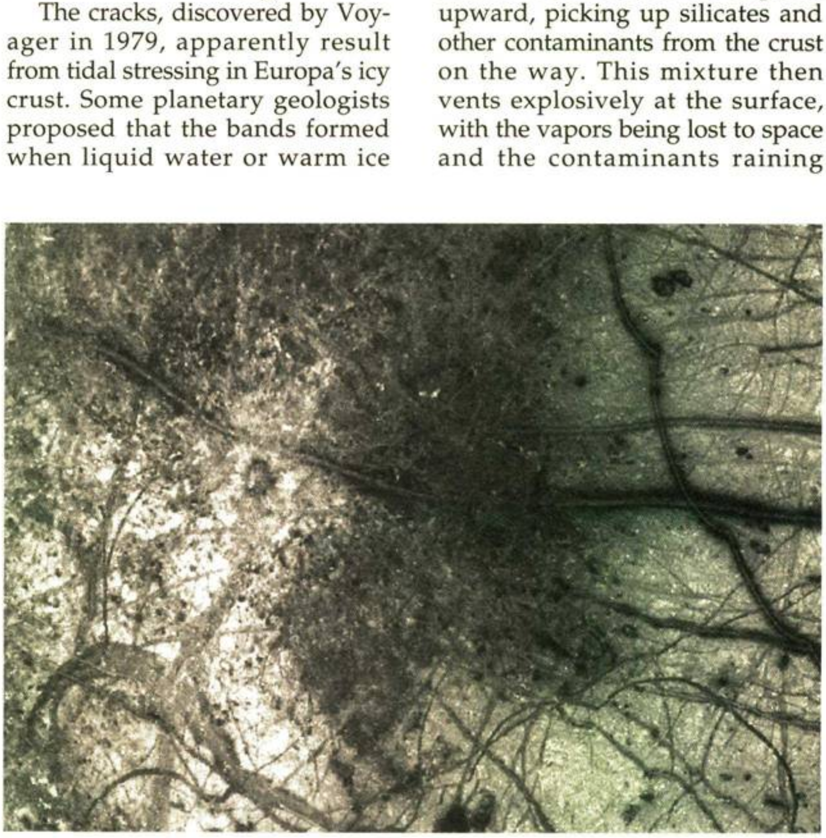
been severely fractured and disrupted, creating features that resemble ice floes seen in Earth's polar seas (see image above). "The ice is broken up into large pieces that have shifted away from one another, but obviously fit together like a jigsaw puzzle," says Galileo imaging team scientist Ronald Greeley of Arizona State University. "This shows the ice crust has been or still is lubricated from below by either slushy ice or maybe even liquid water perhaps only a few kilometers deep." The areas between the plates appear darker because the ice there probably contains some rocky debris. (The images have been processed to bring out detail in features that actually have very subtle contrast.)

How can water ice melt in the frigid environment of the outer solar system? Strong tidal forces from massive Jupiter combine with the gravitational pull of the other jovian satellites to heat the moon's interior. That heat then diffuses out toward the surface.

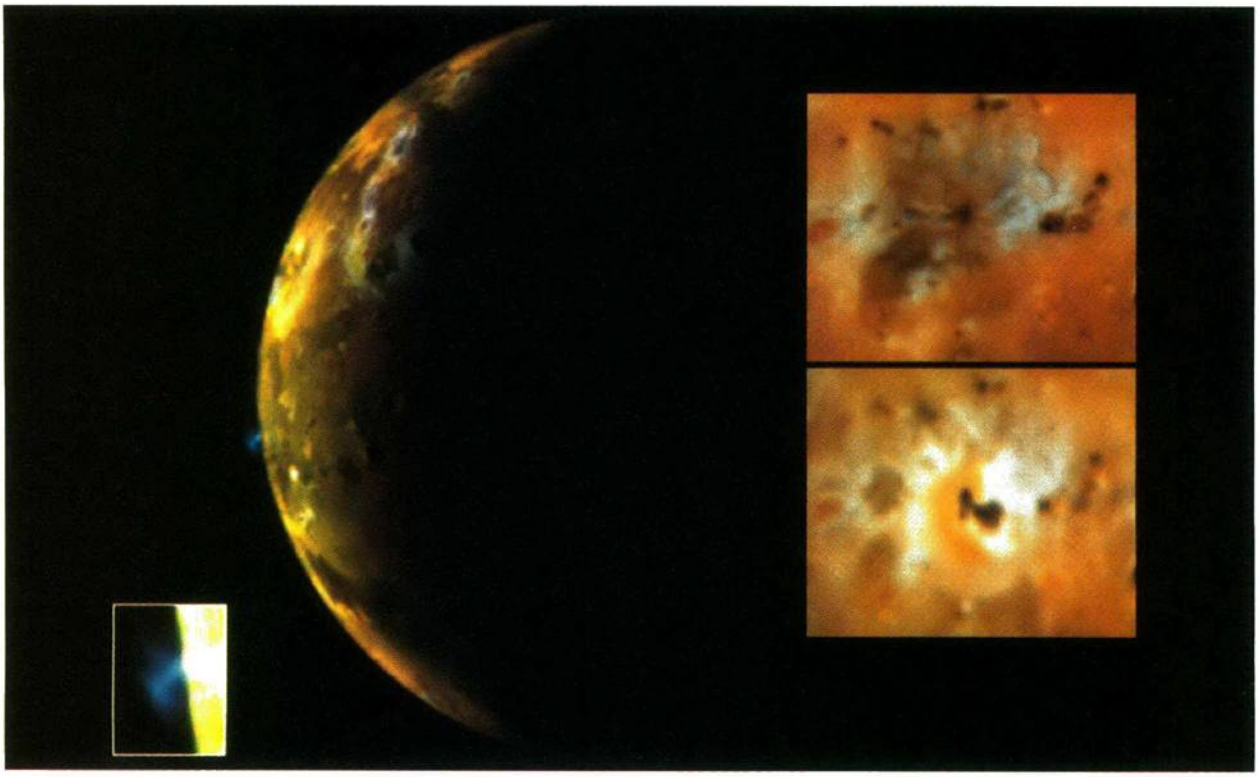
Other signs of activity on Europa include numerous dark spots that could be scars from old geysers, and a vast, nearly global network of stripes often referred to as the "Great Interstate Highway System of Europa." Of particular interest are the triple bands, which are fairly dark "highways" with bright white streaks down their centers. The triple bands are immense, averaging 10 km across and a thousand km long or more.

The cracks, discovered by Voyager in 1979, apparently result from tidal stressing in Europa's icy crust. Some planetary geologists proposed that the bands formed when liquid water or warm ice welled up through surface cracks and then froze. Galileo scientists think the new images, which show details unseen by Voyager, suggest a different model.

In the new scenario, the icy crust first fractures, which allows fluids from below to expand upward, picking up silicates and other contaminants from the crust on the way. This mixture then vents explosively at the surface, with the vapors being lost to space and the contaminants raining



Bright white stripes run down the centers of Europa's triple band features, which probably formed from tidal stresses in the crust. Also notice just to the left of center the 30-km-diameter impact crater and the whitish debris surrounding it.

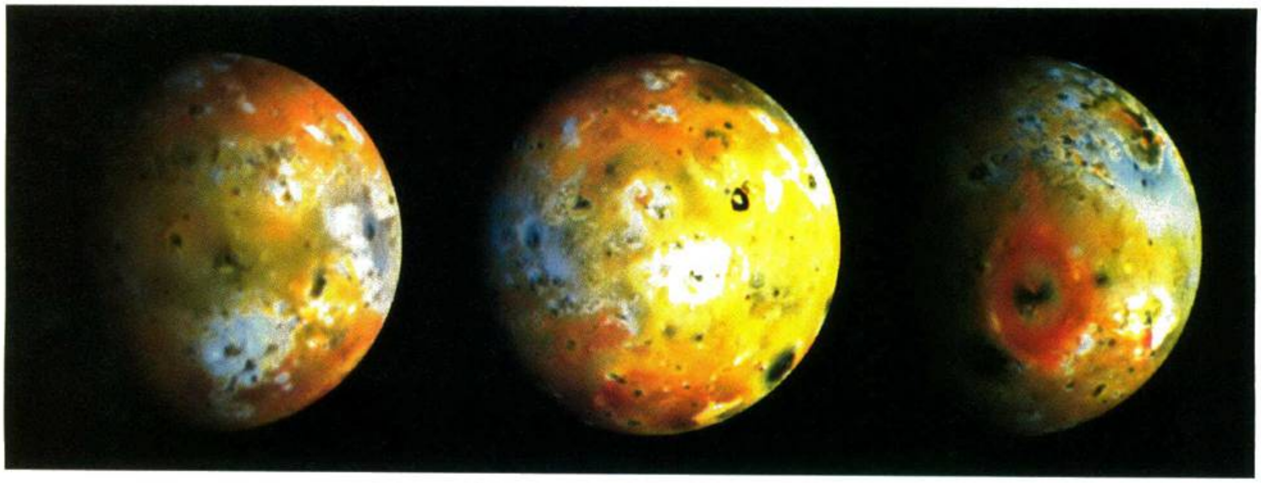


down on the surface, leaving the dark lanes. As the fracture gets flushed clear of contaminants, more pure ice or slush comes to the surface, where it freezes in place to form the bright stripes in the middle. The fracture then freezes shut, halting the process.

Few scientists doubt that Europa has been active in the past. The big question is when, and whether the surface remains active today, implying a liquid or slushy ocean still exists, or the entire crust has frozen solid. Galileo may be able to provide an answer during subsequent flybys. It will catalog impact craters: the more craters (and images seem to show a fair number), the older the surface. It will also search for geysers, soft ice or liquid water under the ice, and any changes in areas imaged by Voyager. The first close-up look at Europa comes on December 19, when Galileo comes 100 times closer than it did in June and will achieve a resolution of 20 meters, good enough to spot features the size of a house.

The combination of liquid water, organic molecules, and heat raise the possibility that life could have gained a foothold on Europa. Greeley admits that the moon might possess environmental

The volcano Ra Patera shoots material 100 km above the crescent limb of Io (above). The blue color indicates that tiny particles make up the plume, probably sulfur dioxide gas and "snow." The two images to the right of Io show the dramatic resurfacing that has taken place at Ra Patera between the Voyager (top) and Galileo (bottom) flybys. The three enhanced-color views (below) cover about 75% of Io's surface. The reddish areas — especially the large oval around Pele in the right image and the intense spot marking Marduk to its right — signify very recent volcanic activity. Also note Ra Patera, the bright whitish area in the middle of the center image, and Loki, the horseshoe-shaped area above and to its right.



niches warm enough and wet enough to host some primitive form of life, but there is certainly no evidence for life.

After snapping Europa's portrait, Galileo next targeted Jupiter's innermost large moon, Io. Squeezed and flexed by much greater tidal forces than Europa is, Io's interior seethes, causing frequent and violent volcanic eruptions that dwarf anything on Earth. One of Galileo's objectives is to monitor the ongoing volcanic activity on Io.

The three images shown (below left) cover about three-quarters of the moon's surface and were taken from a distance of nearly 1 million km. They reveal that in the 17 years since the Voyager flybys, volcanic eruptions have resurfaced about a dozen areas each as large as the state of Connecticut.

The reddish areas mark the sites of recent eruptions. A prominent red oval surrounds Pele, a volcano that ground-based observations have shown to be very active this year. The vivid red spot to the east of Pele is Marduk, which shows major changes since Voyager. Surprisingly, the volcano Loki displays only subtle changes, despite Earth-based observations revealing a high level of activity during much of the past 17 years.

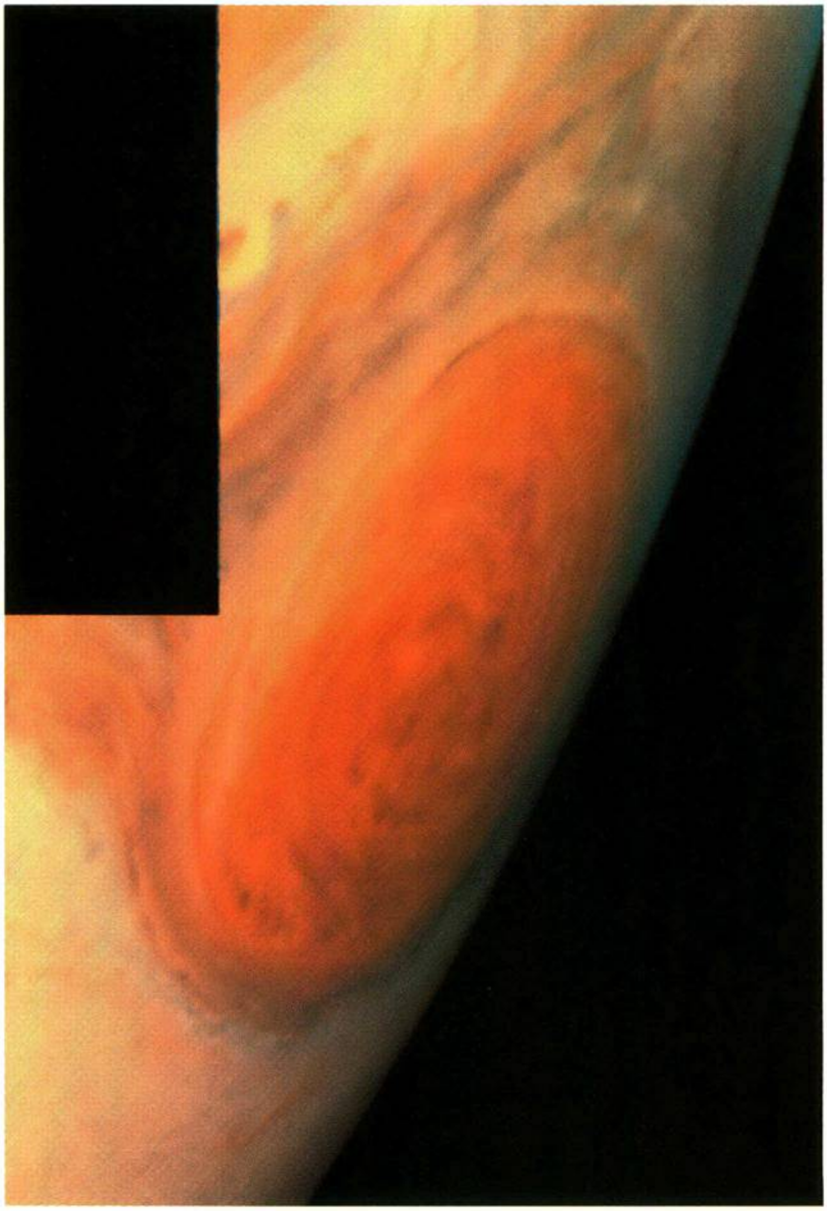
Galileo caught one volcano in the act of erupting. A huge plume extending approximately 100 km above Io's surface could be seen emanating from Ra Patera (see top of previous page). "This is very different from what we see with volcanic eruptions on Earth," says Galileo project scientist Torrence Johnson of JPL. "Terrestrial eruptions cannot throw materials to such high altitudes."

The plume's blue color implies that the ejecta consists of fine particles, perhaps sulfur dioxide gas and "snow" condensing from the gas as the plume expands and cools. The region surrounding Ra Patera also looks remarkably different than in Voyager images. New volcanic deposits there have covered an area of about 40,000 square kilometers, or roughly the size of New Jersey.

The orbiting spacecraft also zeroed in on Jupiter's Great Red Spot, a huge high-pressure system larger than Earth that's been observed in the planet's atmosphere for over 300 years. By taking a pair of photos 70 minutes apart, scientists calculated that the counterclockwise winds blow at 400 km per hour.

But more important, the images show what appear to be thunderstorms near the Great Red Spot. Thunderstorms have long been suspected as a key player in the transfer of energy in the atmosphere, but this marks the first direct evidence of the storms. They appear to tower 50 km above the surrounding clouds and are at least that wide.

Impressive results, to be sure. And this is only the beginning. On September 6, Galileo flew just 250 km above the surface of Ganymede, less than one-third the distance at its June flyby. You can expect to see a preliminary report on that encounter in the January issue. And for the next two years, Galileo will transmit a steady stream of images and other data from Jupiter — get ready for a wild ride. □



The Great Red Spot appears on Jupiter's limb in this two-image mosaic taken through near-infrared and violet filters. Winds circulate around the huge high-pressure system at speeds of 400 km per hour.

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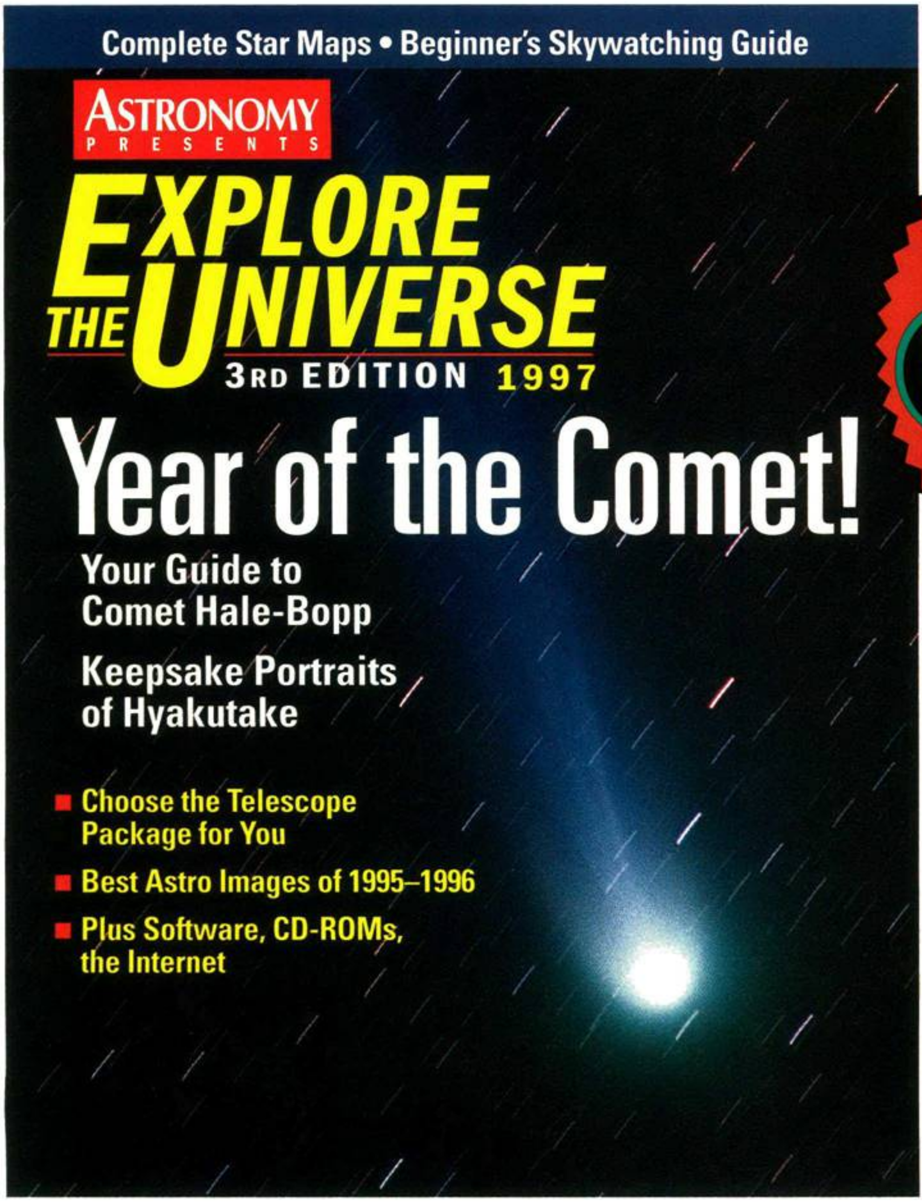
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.965" 2x Barlow	#8740 **$39.95** (2.98)
1.25" 2x Barlow	#8746 **$49.95** (2.98)
2" 2x Barlow	#8724 **$89.95** (3.95)

VariPower 2x–3x Barlow
Our most versatile barlow. Adjusts to any magnification between 2x and 3x. Fully multi-coated optics. 1.25" barrel.
#8748 **$69.95** (3.45)

Shorty™ Barlows
About half the length of our regular barlows for added convenience. Magnifies 2x or 3x when positioned behind or in front of diagonal, respectively, on a refractor or Schmidt-Cassegrain. Works in all scopes, including those in which longer barlows won't work.

.965" Shorty Barlow	#8710 **$49.95** (2.98)
1.25" Shorty Barlow	#8711 **$49.95** (3.45)

TELESCOPE COVERS AND TOTE BAGS

All our scope totes and covers are made of rugged, water-resistant nylon, and are heavily stitched to last.

Soft Scope Cases

These heavily foam-padded carrying cases are real space-savers! Zipper access, with accessory pouch (SC models only) and strap handles.

For SkyView 90mm	#15146 **$98** (4.45)
For SkyView 4.5"	#15148 **$98** (4.45)
For Celestron C5 & Meade 2045D	#15142 **$109** (4.45)
For Celestron, Meade 8" (not LX200)	#15141 **$139** (4.98)
For Meade 8" LX200, LX100, LX50	15144 **$149** (4.98)

Dobsonian Tote Bags

Holds Orion Deep Space Explorer tubes. May also fit some home-built Dobsonians. Nylon drawstring closure. Black nylon shoulder straps.

6" DSE Bag 10"x10"x60"	#15150 **$49.95** (3.41)
8" DSE Bag 12"x12"x62"	#15151 **$54.95** (3.41)
10" DSE Bag 14"x14"x68"	#15152 **$64.95** (3.54)

Tripod & Wedge Bags

Designed to hold Schmidt-Cassegrain tripods & wedges. Handy carry straps.

Economy Tote and Storage Bag
Inexpensive reinforced tote bag without padding. Zippered pocket, nylon drawstring. Length 4' 2", width 1' 5".
#15095 **$34.95** (3.41)

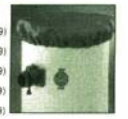
Lightweight Tripod Bag
Fits the Celestron lightweight tripod for C5 and C8+ telescopes (without the wedge). Zippered closure. Inside pocket.
#15143 **$43.95** (3.26)

Field Tripod and Wedge Bag
For Celestron or Meade standard tripod and wedge combinations (not Meade Superwedge or Celestron Ultima wedge). No need to remove the wedge from tripod. Length 4' 2", width 1' 10".
#15096 **$79.95** (5.19)

Deluxe Tripod and Wedge Bag
Fits Ultima tripod with wedge attached.
#15140 **$109** (5.19)

Scope Caps for Deep Space Explorers

Water-resistant soft nylon cap, may also fit other comparably sized Newtonian tubes such as Meade StarFinder.



For 6" DSE	#15180 **$6.50** (2.19)
For 8" DSE	#15181 **$8.95** (2.19)
For 10" DSE	#15182 **$10.95** (2.19)
For 12.5" DSE	#15183 **$14.95** (2.19)
For 16" DSE	#15184 **$18.95** (2.19)

Scope Saver™ Telescope Covers

Water-resistant blue nylon hood protects your scope from the elements. Nylon drawstring closure with cord lock.

For Dobsonian Telescopes. Covers entire tube and base. Great for keeping it covered while not in use, or during transport. Fits Standard or Premium Deep Space Explorers, Newtonian tube assemblies, or home-built telescopes.

6" Standard 9"x12"x54"	#15135 **$34.95** (2.43)
8" Standard 10"x14"x54"	#15136 **$39.95** (2.43)
10" Standard 12"x14"x55"	#15137 **$50.95** (2.43)
10" Premium 12"x12"x64"	#15154 **$59.95** (4.98)
12.5" Premium 17"x17"x74"	#15155 **$69.95** (3.54)
16" Premium 20"x20"x84"	#15156 **$96.95** (4.45)

For SCs and Small Equatorial Telescopes. Fits over the optical tube either on or off the tripod.

8" SC Model Fits any Celestron or Meade 8" Schmidt-Cassegrain telescope. 10"x12"x34"
#15130 **$33.95** (2.43)

10"–11" SC Model Fits Meade 10", Celestron Ultima 11" (not original C-11), and Celestron CG-11 telescopes. 14"x16"x44"
#15131 **$39.95** (2.43)

4.5"–6" Model Fits 4.5" to 6" Newtonian reflectors, such as SkyView 4.5, Celestron 4.5, C6. 6"x22"x38"
#15134 **$37.95** (2.43)

OBSERVING AIDS

Orion FlexiShield™ Dew Caps

Fights moisture buildup. Flexible black material fits snugly around scope tube; Velcro fastener. Rolls up or flattens for convenient storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC	#4200 **$46.25** (2.98)
9-1/4" Celestron SC	#4214 **$48.95** (2.98)
10" Meade SC	#4201 **$57.25** (2.98)

Other sizes available for scopes 3.5" to 14". See our free catalog for details.

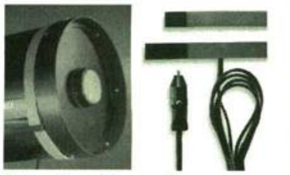
Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside dimensions shown)

Small Case (shown) 11"x7"x3"
#5951 **$19.95** (2.78)

Medium Case 12.5"x9"x5"
#5952 **$27.95** (3.36)

Large Case 16"x11"x5"
#5953 **$42.50** (5.19)



Orion Dew Zapper™

Gently warms perimeter of corrector plate, eliminating dew buildup without "heat wave" disturbances.

8" Dew Zapper fits Meade & Celestron 8" SCs
DC #3503, AC #3504 **$47.95** (2.98)

10" Dew Zapper fits all Meade 10" SCs
DC #3506, AC #3508 **$54.95** (2.98)

11" Dew Zapper fits all Celestron 11" SCs
DC #3510, AC #3512 **$59.95** (2.98)

Orion RedBeam LED Flashlight

NEW!

Astronomically correct red LED preserves dark adaptation. Shock-proof yellow plastic body is easy to find in the dark. Two AA batteries INCLUDED.
#5744 **$11.95** (2.98)

Many more flashlights in our catalog!

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Monterey Bay-Watsonville • 89 Hangar Way, off Airport Blvd. near Santa Cruz • **(408) 763-7000**

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TELESCOPE & BINOCULAR CENTER
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FREE

BINOCULARS

Orion 50mm Vista™

A top-quality astronomical binocular, the Vista features BAK-4 prisms and fully multi-coated optics for high-fidelity images. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. Weighs just 28 oz. Includes hard carrying case.

7x50 6.0° field of view	#9355	**$258** (5.19)
10x50 5.3° field of view	#9353	**$258** (5.19)

Orion 50mm Explorer™

High-performance, economical binoculars with BAK-4 prisms and multi-coatings. Great for both stargazing and daytime viewing. Rubber body coating for sure grip. Includes case, neck strap, and lens caps.

7x50 6.8° Field of View	#9306	**$147** (4.44)
10x50 5.3° Field of View	#9308	**$147** (4.44)

Celestron 8x56, 9x63 Ultima

SALE!

Scanning the night sky is a treat with these large-aperture binos. fully multi-coated, BAK-4 prisms, and long 21mm eye relief. Tripod adaptable. Case and wide neck strap included.

8x56	6.1° field, 31 oz.	~~$349~~	#9596	**$279** (5.71)
9x63	5.4° field, 35 oz.	~~$389~~	#9542	**$329** (5.71)

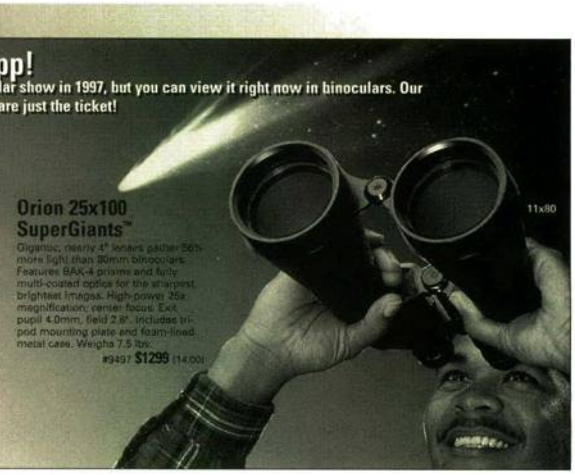
Orion 50mm UltraView™

The perfect binocular for eye- and sunglass wearers. Extra-long 23mm eye relief and unique pop-down eyepiece guard. Fully multi-coated optics for high light transmission and maximum contrast. BAK-4 prisms. Close focus 16'. Weighs 32 oz. Includes soft nylon case, eyepiece rain shield, and neck strap.

7x50 6.5° Field of View	#9357	**$188** (4.95)
10x50 6.5° Field of View	#9351	**$188** (4.95)

Catch Comet Hale-Bopp!

Hale-Bopp promises to put on a spectacular show in 1997, but you can view it right now in binoculars. Our Little Giant™, Giant, or SuperGiant™ binos are just the ticket!



Orion 70mm Little Giants™

The standard for hand-holdable high-power astronomy binoculars. Fully multi-coated. Terrific brightness and edge sharpness! Weighs only 58 oz. Includes tripod mounting adapter and deluxe hard case.

10x70 #9501, **14x70** #9494 **$369** (6.97)

Orion 80mm Giant Binoculars

For jaw-dropping views of the heavens and Earth, our wide-aperture Giants can't be beat. Fully multi-coated optics and BAK-4 prisms provide fantastic contrast and edge sharpness. 20% more light transmission than "fully-coated." Includes deluxe hard case with handle and shoulder straps.

11x80 Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable.
#9502 **$469** (8.05)

16x80 Excellent for astronomy and daytime observation.Tripod recommended.
#9496 **$469** (8.05)

20x80 Highest-power model, perfect for smaller deep-space objects and long-range daytime views. Tripod required.
#9498 **$469** (8.05)

Orion 25x100 SuperGiants™

Gigantic, nearly 4" lenses gather 56% more light than 80mm binoculars. Features BAK-4 prisms and fully multi-coated optics for the sharpest, brightest images. High-power 25x magnification; center focus. Exit pupil 4.0mm, field 2.6°. Includes tripod mounting plate and foam-lined metal case. Weighs 7.5 lbs.

#9497 **$1299** (14.00)

QUALITY COMPONENTS

6x30 Achromatic Finder Scope

6x30mm Straight Includes 2-ring metal bracket, fits scopes 6"–12".
#13023 (white)
$49.95 (3.41)

Large-Aperture Finder Scopes

High-quality finders at very reasonable prices! Wider apertures for brighter views. Fully coated achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) **$79.95** (3.41)

8x50mm Illuminated Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) **$119** (3.41)

9x60mm 44% more light grasp than 50mm models.
#7091 (white) #7095 (black) **$119** (3.41)

9x60mm Illuminated Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) **$159** (3.41)

Low-Profile Helical Focusers

Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded, machined aluminum inner tube.

1.25" Helical Focusers	#13014	**$39.95** (2.45)
2" Helical Focusers	#13016	**$59.95** (2.98)

Rack-and-Pinion Focusers

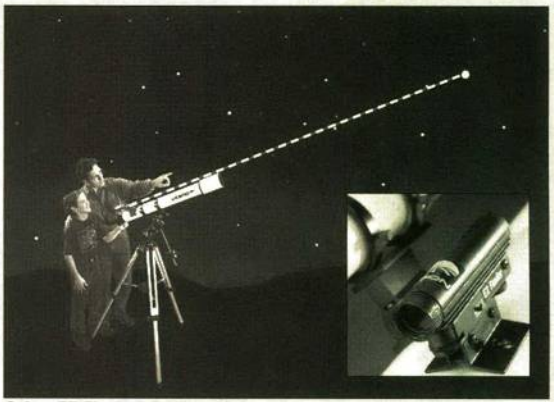
Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long-focus travel.

1.25"	#13007	**$69.95** (2.98)
2" includes 1.25" adapter	#13003	**$119** (3.95)

Dovetail Mounts for 50mm and 60mm Finder Scopes

Instantly install or remove your finder, without tools, without disturbing alignment! Black-anodized aluminum fits any scope 6" or larger including Celestron and Meade Schmidt-Cassegrains.

8x50mm Dovetail Mount	#5040	**$39.95** (2.45)
9x60mm Dovetail Mount	#5041	**$47.95** (2.98)
Extra Dovetail Mount Base	#5050	**$14.95** (2.19)



Orion EZ Finder™ Reflex Sight

This nifty device makes pointing a telescope almost as easy as pointing your finger. Keep both eyes open and look through EZ Finder, and you'll see the image of a red dot projected at infinity, showing exactly where the telescope is aimed in the sky.

Installs on any telescope in minutes. Wide 10° field of view, low and high brightness settings. Fits Meade and Celestron Schmidt-Cassegrain scopes in existing mounting holes; attaches easily to other scopes. Weighs just 2.5 oz.

#7075 **$49.95** (3.45)

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine-polished, coated twice: with aluminum and silicon monoxide. Very competitively priced!

Standard Primary Mirrors
Fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed ±1/8 wave. Sizes: 4.5" f/10, 6" f/8, 8" f/6, 10" f/4.5, 10" f/5.6, 12.5" f/4.8. Call for pricing.

Pyrex Low-Expansion Mirrors
Fine annealed Pyrex brand low-expansion glass, 1:6 thickness ratio. ±1/10 wave. Available with standard or 94% reflectivity, enhanced aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6, 16" f/4.5. Call for pricing.

Elliptical Secondary Mirrors

Fine annealed Pyrex brand glass, aluminized and SiO overcoated. ±1/10 wave accuracy. Available with standard- or high-reflectivity enhanced aluminum coatings. Ten sizes from 0.75" to 4.00" minor axis. Call for pricing.

Astrositall Zero-Expansion Mirrors

Astrositall is a glass-ceramic material with an ultra-low coefficient of thermal expansion. Ideal for harsh environmental conditions. 1:7 thickness ratio. ±1/10 wave surface accuracy. Enhanced aluminum coatings.

Astrositall Parabolic Mirrors 6" f/8, 6" f/5, 8" f/6, 10",f/6

Astrositall Elliptical Flat Mirrors 1.30", 1.52", 1.83", 2.14". Call for pricing.

We also carry Sonotube Newtonian optical tubes, Dob altitude bearings, mirror cells, and other telescope components. See our catalog.

ACCESSORIES

Many More Accessories in Our 100-Page Color Catalog!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965"	#5268	**$29.95** (2.98)
1.25"	#5264	**$29.95** (2.98)
Hybrid 1.25"/.965"	#8782	**$29.95** (2.98)

Variable-Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25"eyepiece holders.

#5262 **$39.95** (2.98)

Orion Slow-Motion Adapter

Attaches to your photo tripod pan head. Two slow-motion control knobs to make precision adjustments in altitude and azimuth. Very handy for tracking planets, the Moon, and constellations with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7033 **$39.95** (2.19)

Tele-Extenders for Schmidt-Cassegrain Scopes

For high-powered photography with your Meade or Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender	#5125	**$29.95** (2.98)
Variable Tele-Extender	#5127	**$39.95** (2.98)

T-Adapters for SC and MAK

Threads to rear cell of telescope, requires T-ring for your camera model.

For SC	#5116	**$26.95** (2.98)
For C90	#7115	**$34.95** (2.98)

T-Rings for 35mm Cameras

Available for many different camera types; call toll-free or see our catalog for your particular model.

45° Correct-Image Diagonal Prisms

Ideal for all refractors and compound telescopes used for terrestrial viewing.

.965" Diagonal	#8791
1.25" Diagonal	#8790
Hybrid 1.25"/.965"	#8792

$44.95 each (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals are ideal for refractors and Schmidt-Cassegrains.

.965" Star Diagonal	#8761	**$29.95** (2.98)
1.25" Star Diagonal	#8763	**$39.95** (2.98)
Hybrid 1.25"/.965"	#14008	**$39.95** (2.98)
1.25" Correct Image	#8787	**$89.95** (2.98)

Orion Ultra™ 2" Diagonals

2" Prism Diagonal Absolutely the finest-quality multi-coated 2" prism for highest light transmission.

For refractors #8770, for Schmidt-Cassegrain #8771
$219 (4.71)

2" Mirror Diagonal Affordable, high-quality first-surface optical flat star diagonal.

For Schmidt-Cassegrain #8772 **$109** (3.45)

Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute set-up—no polar alignment or levelling.
- Observe hundreds of objects in just a few hours!
- For ANY telescope, with or without a motor drive. Even altazimuth or Dobsonian scopes!
- Digital display of celestial coordinates (RA and Dec).
- Built-in electronic sky catalog—find objects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a 9v battery or external 12v power supply (not included).

Sky Wizard Model 1
Database includes all 110 Messier objects, 28 stars, and the planets. Weighs just 4 oz.
#7801 **$179** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice. Weighs just 6 oz.
#7802 **$249** (4.44)

Sky Wizard Model 3
Gigantic 10,000 object database, including entire NGC and IC and 837 interesting double and variable stars. Expanded object descriptions, RS-232 port.
#7803 **$349** (6.78)

Complete system requires Sky Wizard Model 1, 2, or 3, and a telescope installation package, sold separately.

Installation Packages

Includes two encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions. Installation packages are available for most telescope models. Call for details.

from $166

If You Take Your Computer With You . . .

NEW! Sky Wizard CTI

Computer–Telescope Interface

This handy, portable device connects the encoders on your telescope directly with your computer, allowing you to monitor your telescope's location with **TheSky** and **Deep Space** software programs (not included). Interface not needed with SkyWiz 3.
#7810 **$149** (4.11)

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SKY ALMANAC

The month opens with Jupiter and its Moon-sized companions balanced near a celestial teaspoon. Farther east, the Ringed Planet slowly but surely regains the resplendence of its namesake rings.

by Martin Ratcliffe

Highlights
by Alister Ling

Date	Event
2	Luna and a Distant Star Cluster . . .(p. 72)
12	An Archer's Crescent Encounter . . . .(p. 73)
16	Thanksgiving's Leonid Meteors . . . . . .(p. 73)

all month:

First Views:
Star Clusters of Fall . . . .(p. 69)
Observer's Challenge:
The Pinwheel's Star Factories . .(p. 70)
Hot on Hale-Bopp . . . . .(p. 71)
November's Asteroid Offering . . . .(p. 72)

Take your telescope out this month for a last chance in 1996 to get a steady view of Jupiter, the largest planet of the solar system .In fact, all four of the giant planets congregate in the evening sky. Uranus and Neptune are within range of a small telescope, not far from the king of the planets. Saturn, the solar system's second largest planet, hovers in the east after sunset.

Add brightening Comet Hale-Bopp to the planetary mix and you're in for a fine night's viewing.

Jupiter is the first evening planet to shine forth during dusk at a brilliant magnitude –2.0. It's low in the southwest below the "teaspoon" asterism in northeastern Sagittarius, a grouping of stars formed by Pi (π), Xi (ξ), and Omicron (o) (see "An Archer's Crescent Encounter").

The teaspoon owes its popularity to those who look for Sagittarius' aptly named "teapot" asterism, for what good would tea be without a spoonful of sugar in the form of a crystalline portion of the Milky Way? Sagittarius' misty star clouds also portray steam pouring out of the teapot's spout, which tilts toward the southwestern horizon during evening twilight.

Both Jupiter and its tea service set four hours after the Sun as November begins, and just three hours after the Sun by the 30th.

The planet's low altitude in Earth's churning atmosphere, particularly by late month, affects the amount of detail we see on and around the planet's large disk through a telescope. But there's still plenty to glean.

Have you ever seen a satellite or its shadow transit Jupiter? A satellite transit happens when one of Jupiter's four large moons, called the Galilean satellites, passes along our line of sight with the planet. A sharp eye through even a 4-inch telescope can follow these jovian satellites as they cross their home world's face.

A moon's shadow comes into view as a black dot on Jupiter's clouds soon after the satellite begins its transit. Satellite and shadow events graphically demonstrate gravity at work around Jupiter, the

Jupiter gleams in the southwest after sunset on November evenings. Use a telescope to witness the nightly motion of Jupiter's four large moons. Next month Jupiter sinks too low into Earth's blurry atmosphere for us to see any meaningful detail.

D.C. Parker

1996
NOVEMBER

1 Mercury is in superior conjunction, 7 p.m. EST

3 Last quarter Moon is at 2:50 a.m. EST
The Moon is at apogee (404,312 kilometers from Earth), 8:39 a.m. EST

5 The Moon passes 5° south of Mars, 3 a.m. EST

8 The Moon passes 1.4° south of Venus, 5 a.m. EST

10 New Moon is at 11:16 p.m. EST

14 The Moon passes 5° north of Jupiter, midnight EST

15 The Moon passes 4° north of Neptune, 6 p.m. EST
The Moon is at perigee (369,460 kilometers from Earth), 11:43 p.m. EST

16 The Moon passes 5° north of Uranus, 4 a.m. EST
Venus passes 4° north of Spica, 1 p.m. EST

17 Leonid meteor shower peaks
First quarter Moon is at 8:09 p.m. EST

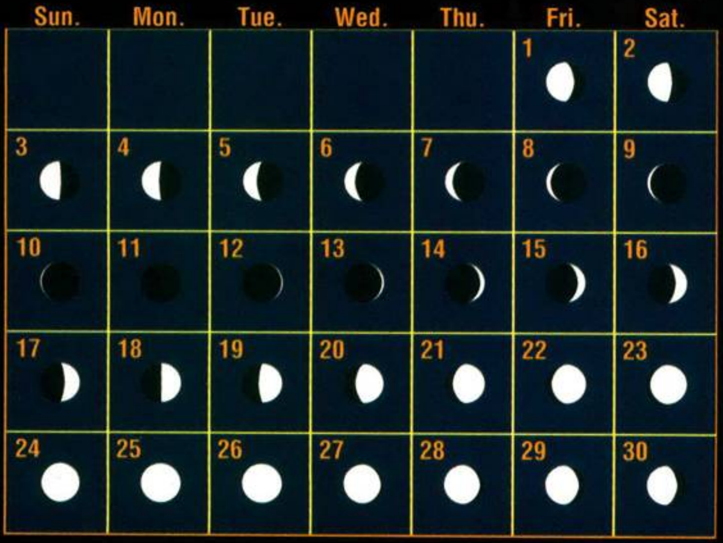
19 Asteroid Davida is at opposition

20 The Moon passes 3° north of Saturn, 10 a.m. EST
Mercury passes 3° north of Antares, noon EST

23 Asteroid Interamnia is at opposition

24 Pluto is in conjunction with the Sun, 7 p.m. EST
Full Moon is at 11:10 p.m. EST

25 The Moon passes 0.9° north of Aldebaran, noon EST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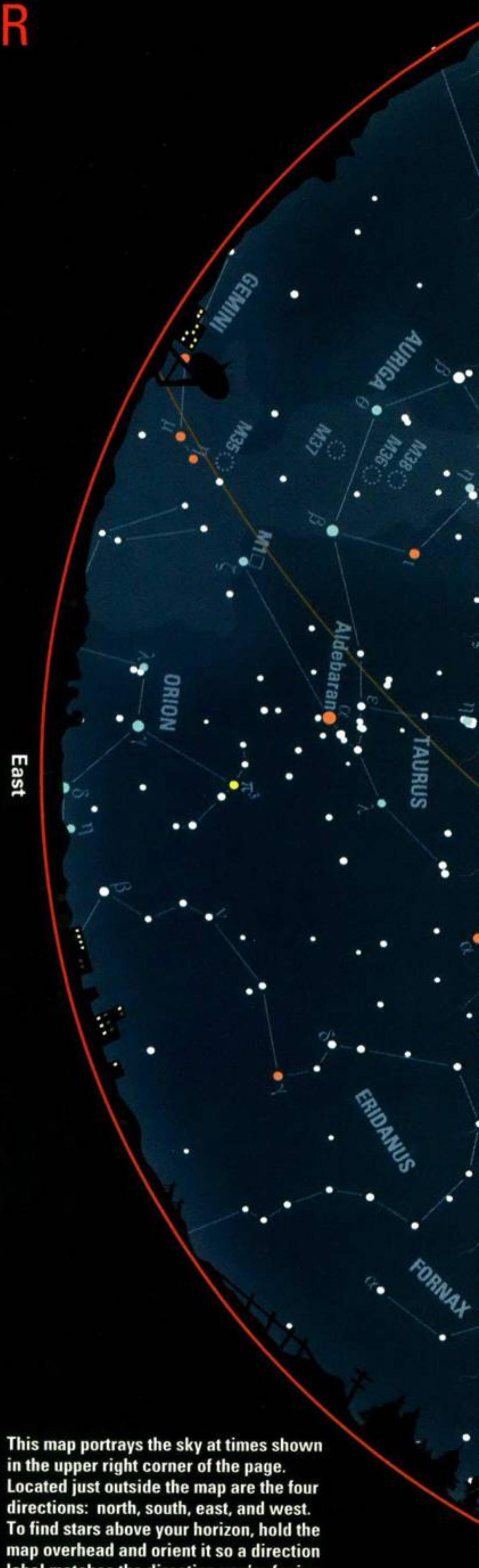
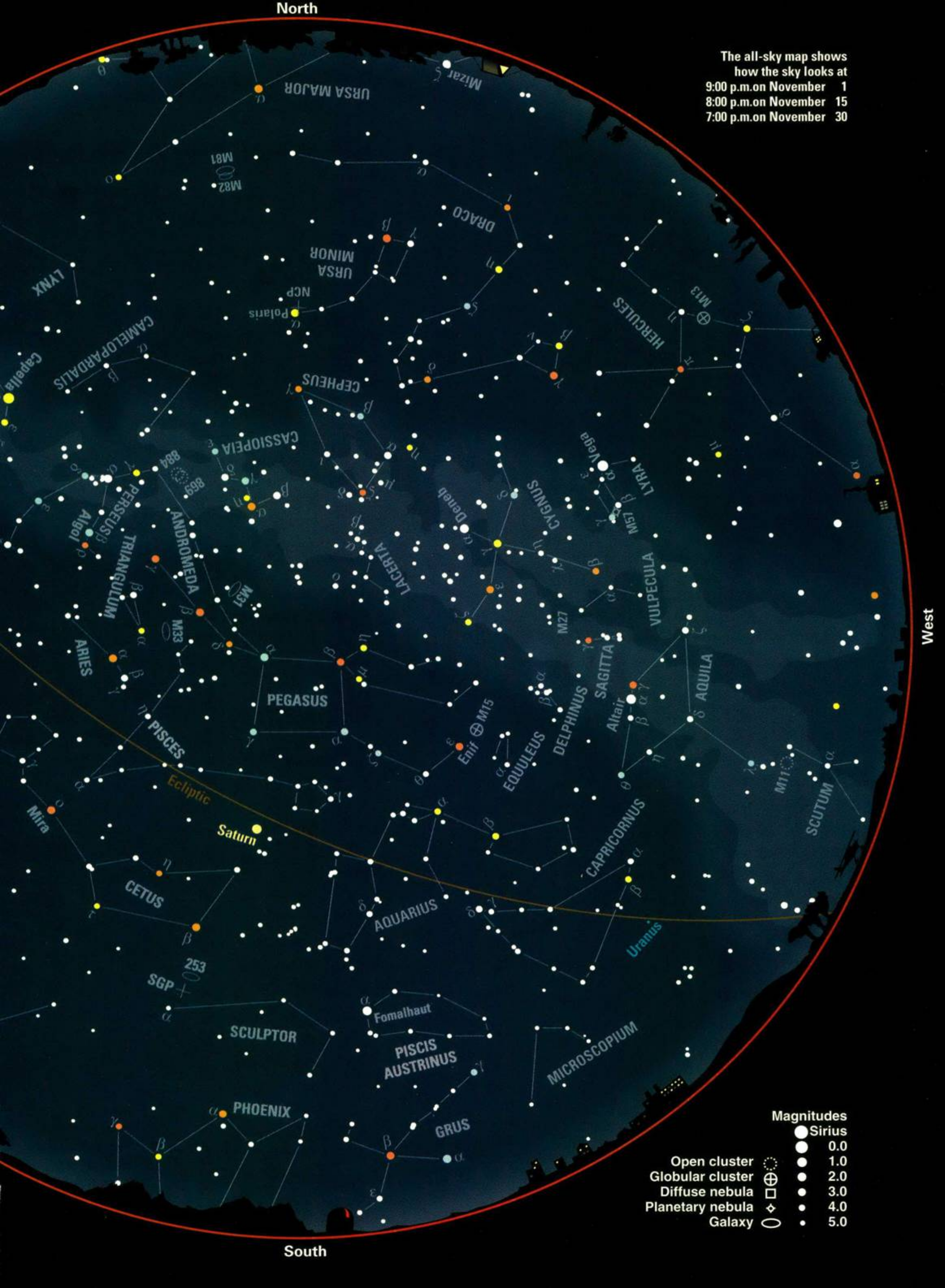
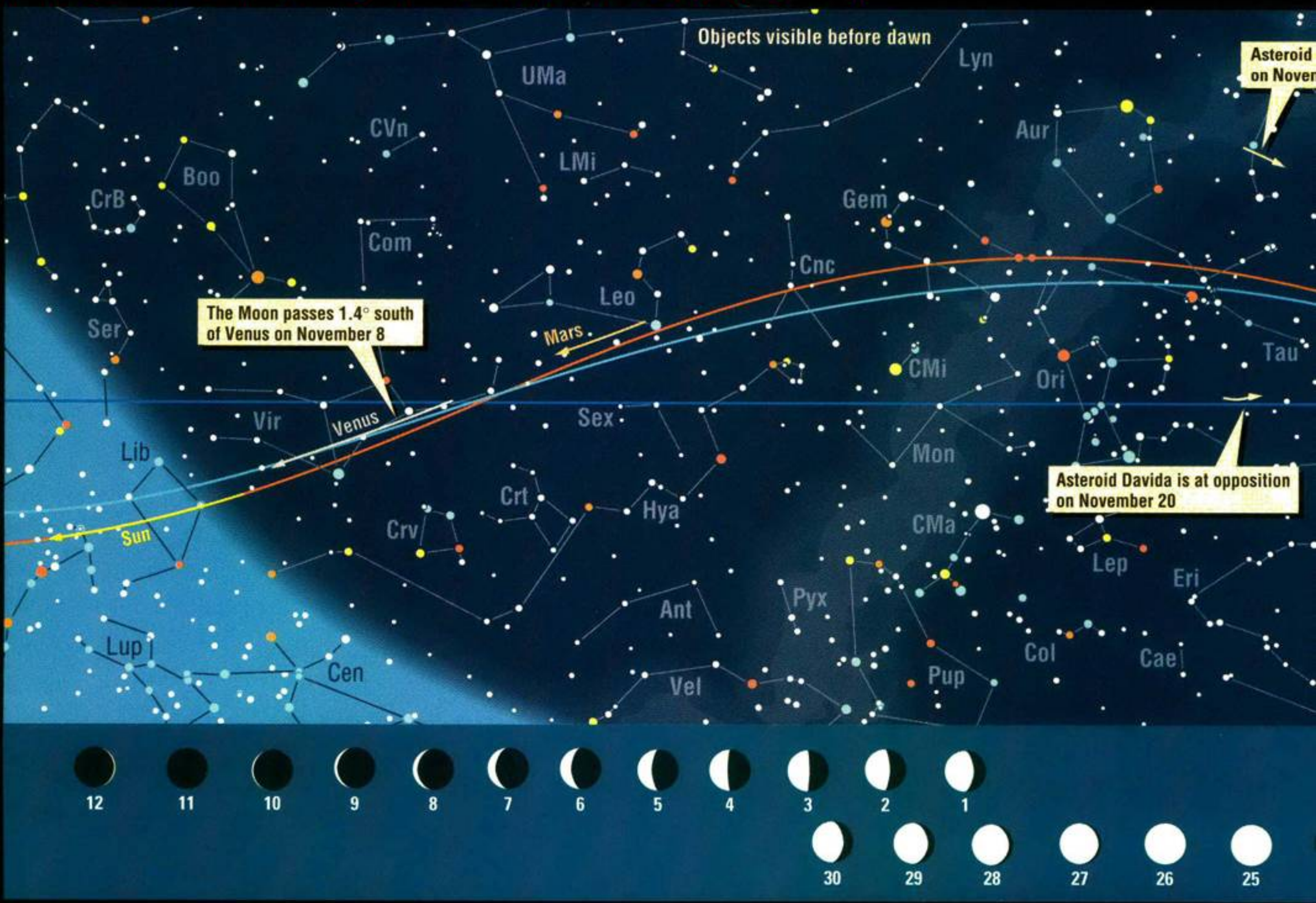

GEMINI
AURIGA
M35
M37
M36
M38
M1
Aldebaran
ORION
TAURUS
ERIDANUS
FORNAX
East

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
9:00 p.m. on November 1
8:00 p.m. on November 15
7:00 p.m. on November 30


North
South
West
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
HERCULES
M13
CEPHEUS
CASSIOPEIA
Vega
LYRA
M57
884
869
PERSEUS
Algol
ANDROMEDA
TRIANGULUM
M31
M33
Deneb
CYGNUS
LACERTA
VULPECULA
M27
SAGITTA
ARIES
PEGASUS
Altair
AQUILA
DELPHINUS
EQUULEUS
Enif
M15
PISCES
M11
SCUTUM
Ecliptic
Mira
Saturn
CAPRICORNUS
CETUS
AQUARIUS
Uranus
253
SGP
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Objects visible before dawn

The Moon passes 1.4° south of Venus on November 8

Asteroid Davida is at opposition on November 20

Asteroid
on Nover

UMa
Lyn
CVn
LMi
Aur
Boo
CrB
Com
Gem
Cnc
Leo
Ser
Mars
CMi
Tau
Ori
Vir
Venus
Sex
Lib
Mon
Crt
Hya
Sun
Crv
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Pyx
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Cen
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Cae
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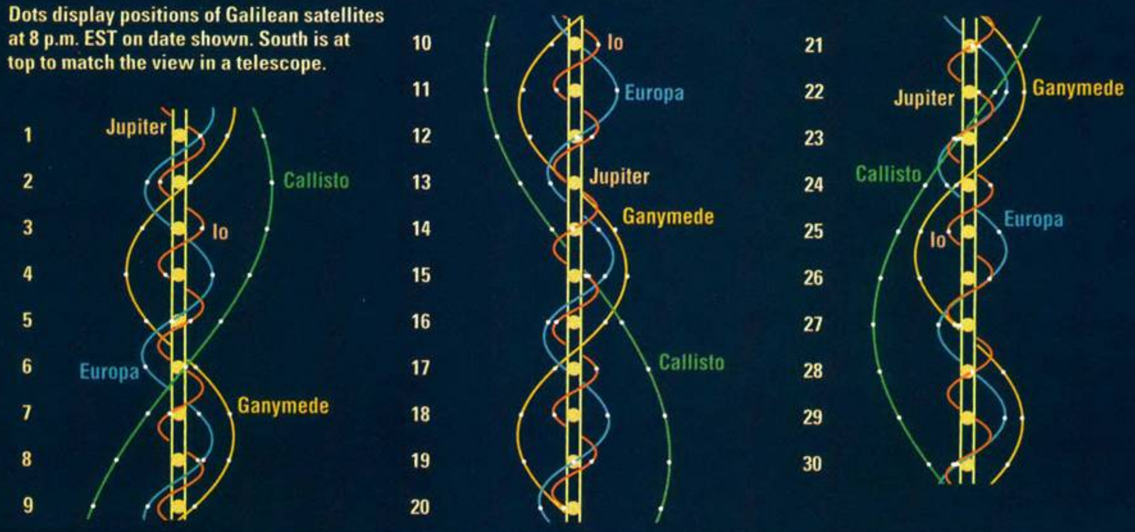
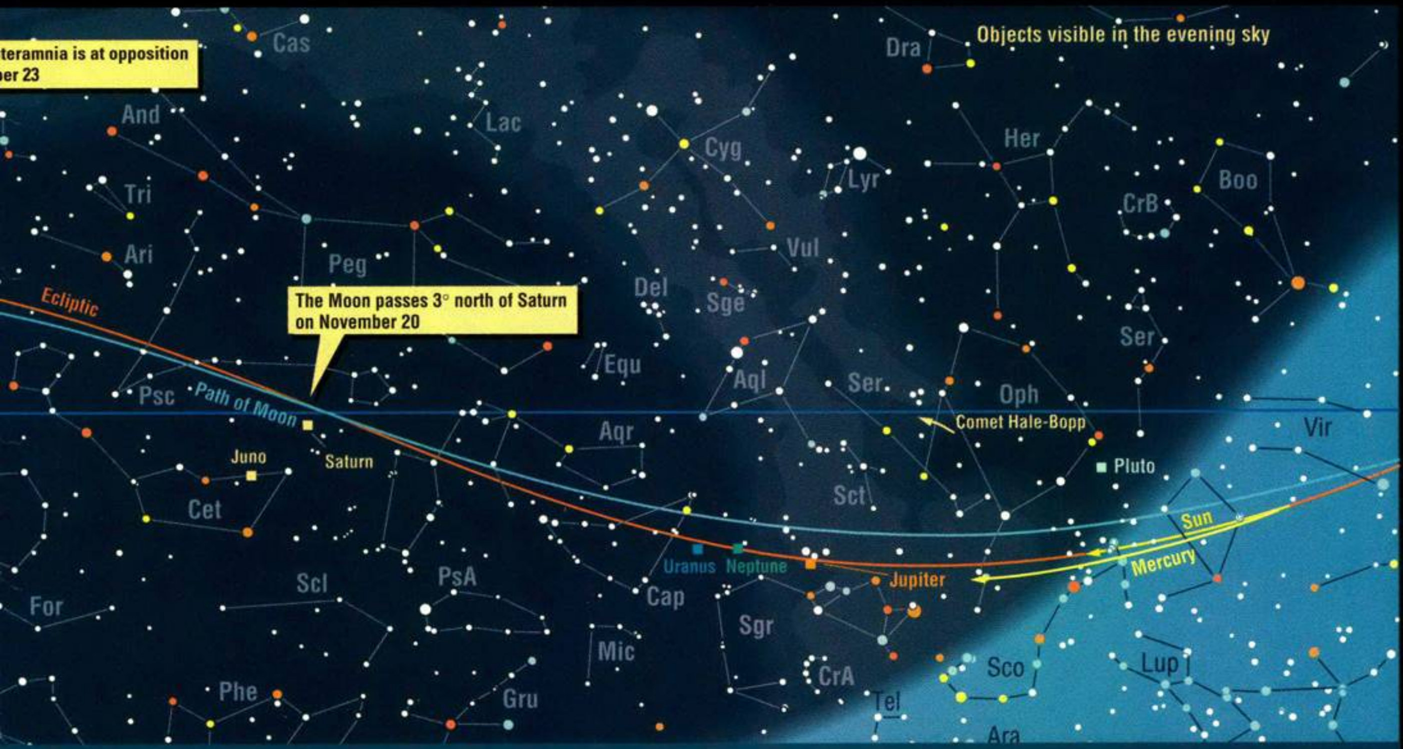
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	November 15	November 30	November 15	November 15	Novembe
Magnitude	–0.7	–0.7	–4.0	1.1	–2.0
Angular Size	4.7"	4.7"	12.8"	5.9"	34.6"
Illumination	98%	98%	83%	91%	99%
Distance (AU) from Earth	1.428	1.428	1.309	1.598	5.699
Distance (AU) from Sun	0.467	0.467	0.719	1.639	5.154
Right Ascension (2000.0)	15h52.5m	15h52.5m	13h17.1m	10h43.3m	19h06.4
Declination (2000.0)	–21°20'	–21°20'	–6°12'	10°04'	–22°50'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 8 p.m. EST on date shown. South is at top to match the view in a telescope.




teramnia is at opposition
ber 23
Cas
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Psc
Juno
Saturn
Cet
For
Scl
Phe
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Gru
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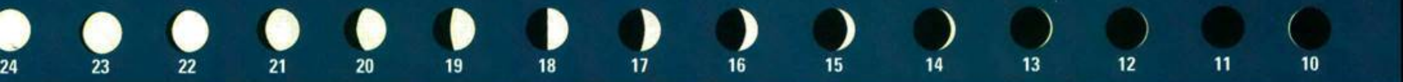
Equ
Aql
Aqr
Cap
Mic
Uranus
Neptune
Sgr
CrA
Tel
Ara
Sct
Ser
Oph
Comet Hale-Bopp
Pluto
Jupiter
Sun
Mercury
Sco
Lup
Vir

Objects visible in the evening sky

The Moon passes 3° north of Saturn on November 20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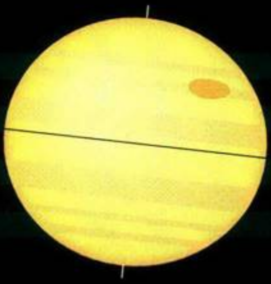
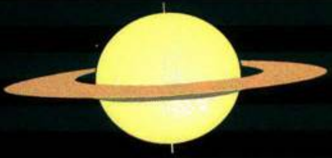
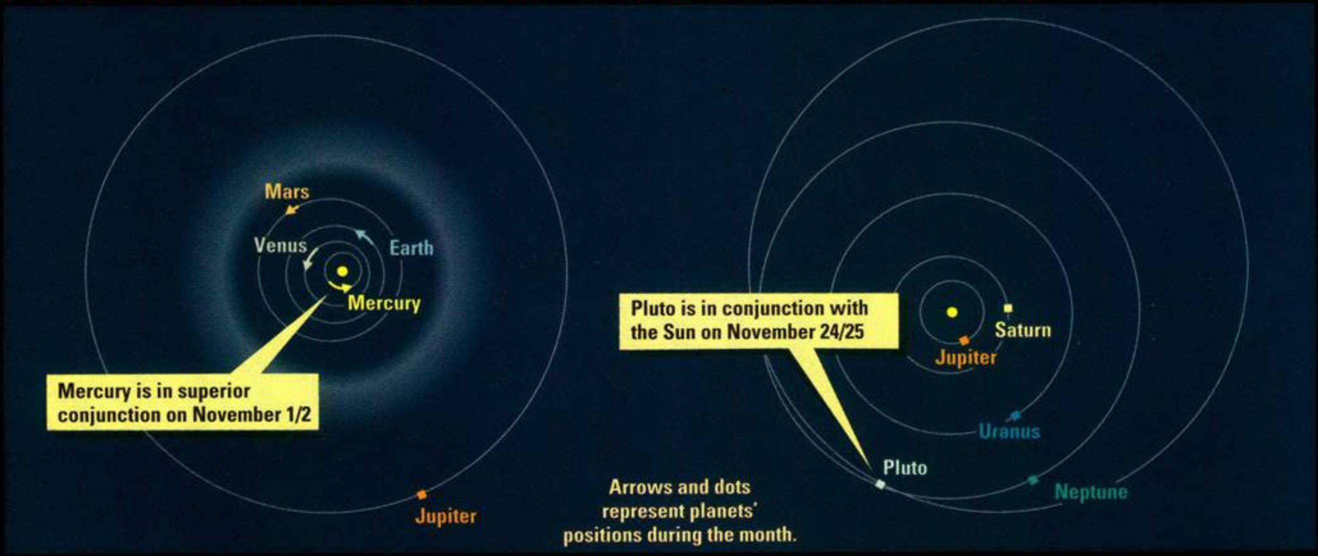




	SATURN	URANUS	NEPTUNE	PLUTO
15	November 15	November 15	November 15	November 15
	0.8	5.8	8.0	13.8
	18.8"	3.5"	2.2"	0.1"
	100%	100%	100%	100%
	8.844	20.136	30.601	30.889
	9.485	19.791	30.157	29.938
	0h07.5m	20h14.4m	19h49.3m	16h12.1m
	–1°57'	–20°27'	–20°37'	–8°32'

THE PLANETS IN THEIR ORBITS


Mars
Venus
Earth
Mercury
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mercury is in superior conjunction on November 1/2

Pluto is in conjunction with the Sun on November 24/25

Arrows and dots represent planets' positions during the month.

same force that holds planets within their orbits throughout the solar system as well.

A few transit events happen this month right after dinnertime. For east-coasters, try the evening of November 7, when Io, Jupiter's innermost Galilean satellite, moves in front of Jupiter's disk at 6:18 p.m. EST. An hour and five minutes later Io's black shadow falls upon the planet's cloudtops. Io clears the disk by 8:33 p.m., while the shadow lingers until 9:38 p.m.

A similar sequence is visible from the west coast of North America on November 14, beginning during twilight at 5:17 p.m. PST; Jupiter sets with Io's shadow still on the planet.

Closer to home, look for our own Moon, a 4-day old crescent, passing 5 ½° northwest of Jupiter on November 14. It occults the open cluster M23 for the western half of the North American continent the night before.

While in the area, swing your telescope 10° east of Jupiter to capture **Neptune**. You'll find it lurking just over a degree southeast of 5th-magnitude 56 Sagittarii, perhaps just inside the same low power field of view.

At magnitude 8.0, this giant outer planet currently lies 4.5 billion kilometers from the Sun, farther out than Pluto. It remains the most distant planet from our Sun until 1999, when that accolade returns to Pluto's ownership.

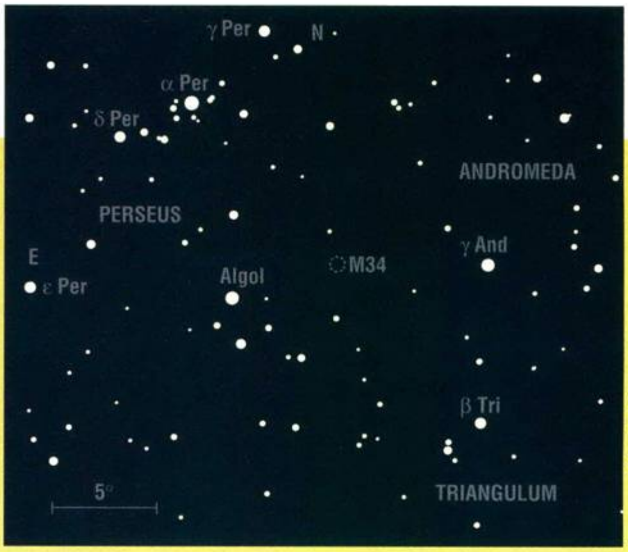
A pair of binoculars picks up **Uranus** 6° farther east of Neptune, across the border of Sagittarius in Capricornus. If you have a hard time holding 7x50 binoculars steady, mount them on a tripod.

Uranus is physically similar in size to Neptune, but more than a billion km closer and hence brighter at magnitude 5.8. Uranus shows a blue-green disk in a telescope with medium magnification. Neptune, however, reveals little more than a blue-gray star-like image, even when viewed at high power.

Saturn is already high in the south by the time Jupiter and the other giant planets set, swimming through the heavens flanked by Pisces the Fish to the north, Cetus the Whale to the south, and Aquarius the Waterbearer to the west.

These watery constellations remind us that Saturn's average density is only 70% of water. If the

First Views:
Star Clusters of Fall



ASTRONOMY: Elisabeth Rowan

No deep-sky objects are splashier and brighter than star clusters, perhaps the easiest target to find through the glare of city lights. Open and globular star clusters are held together by a bond of gravity into groupings of a handful, a dozen, a hundred, or even a million stars.

Open clusters, like M34 in Perseus, are loosely-knit groupings of young stars born into our Galaxy's spiral arms, some only a few million years ago.

Globular clusters like M15 in Pegasus (consult the Star Dome map for its location) harbor some of the oldest stars in the universe, and orbit outside the hub of our galaxy.

The 60 stars that make up M34 lie about 1,400 light-years away, and shine with a total apparent brightness of magnitude 5.2. This means you can see M34 with the unaided eye at any site away from the city.

In contrast, M15 lies some 34,000 light-years away, but its countless stars yield an apparent brightness of 6.0. Indeed, under excellent skies it can be just glimpsed with the naked eye as a faint spot next to a nearby star of similar brightness.

Even the slightest optical aid shows each object's true nature. Binoculars immediately reveal M34 as a few stars surrounding a fuzzy central clump.

A small telescope shows a delightful compact central area of 15 to 20 equally bright stars, surrounded by a thin shell of 10 more stellar points. Bigger scopes pull in still fainter stars.

Globular cluster M15 looks totally different in binoculars: a small, round, gray cotton ball. You'll need a 4-inch scope under dark skies to reveal M15's splendor of hundreds of pinpoint stars on an unresolved glow of fainter stars.

Every inch of telescope aperture brings in literally hundreds more stars. Amazingly, the stars just get more and more jam-packed as you zero-in on the cluster's core.

Use the highest power your scope and Earth's atmosphere will allow to give you a spacey 3-D feel. — *Alister Ling*

Robert Provin

Lee C. Coombs

Observer's Challenge:
The Pinwheel's Star Factories

Space is humbling. The view through a small telescope of the Orion Nebula, a nearby star factory giving birth to hundreds of solar systems, leaves us awestruck.

But as we turn our telescopes deeper into the universe, we confront the incredible reality that M42 is but a dot compared to the massive nurseries churning away in M33, the neighboring Pinwheel Galaxy in Triangulum.

At the Pinwheel's distance of 3.6 million light-years, our mighty Orion Nebula would be roughly 1,000 times smaller than most of its M33 counterparts. In other words, M42 would be invisible.

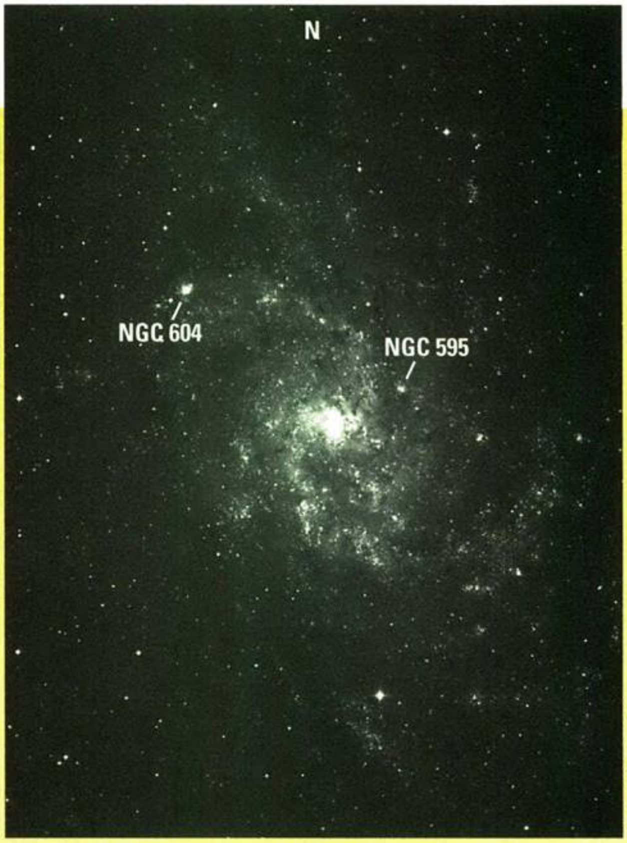
All stars are born in large glowing gas clouds like M42, called H II (pronounced "H-two") regions. Blazing, massive newborn stars that emit copious amounts of ultraviolet light make hydrogen gas in their cocoon glow in an ionized, H II state. M33's spiral arms are brimming with H II regions visible through even a medium-sized telescope.

Even a 3-inch scope has no problem revealing the brightest H II region of M33, so bright that earlier observers gave it its own NGC number, NGC 604. Incidentally, the area's even visible in moonlight when the parent galaxy is invisible!

Look for NGC 604 on the northeast side of M33, just south of a similarly bright star. At powers over 100x, it appears as a fuzzy patch of light 2 to 3 arcminutes across. Don't be afraid to apply higher power, say 200x, with an 8-inch or larger scope to look for some mottled structure.

A few arcminutes west of M33's core is the next brightest H II region, NGC 595. Other, still fainter H II regions that don't have NGC designations will become visible if your scope is motorized to track with the sky, which allows you to concentrate.

The best way to glimpse these fainter H II regions is to use high power on a 10-inch or larger telescope. Drape a dark cloth over your head to cloak out the stray light. All the clumps you'll see along M33's spiral arms are huge star factories.



Kitt Peak National Observatory

One valuable tool in your search for H II regions is a nebular filter. It blocks out unwanted light while passing subtle light from the glowing gas. Move the filter back and forth between your eye and eyepiece so foreground stars and M33's stellar spiral arms fade in and out while the many H II regions remain visible.

Use the photo above to make what seasoned observers call a "wire-frame trace" of some key stars. Then, at the eyepiece, sketch in as many H II regions as you can find.

Compare what you draw with what the photo reveals. Be sure to file away the rendering; have someone at the next dark sky star party you attend train a big scope, like a 20-inch, on the Pinwheel. What it reveals will be a sight you'll never forget! — *A. L.*

ocean of space were filled with water, Saturn would be the only planet afloat; the rest would sink.

Saturn remains visible all evening, setting an hour after midnight by November 30. The rings appear very fine, nearly edge-on through a telescope.

Its brightness dims a couple of tenths of a magnitude to 0.8, caused in large part by its increasing distance from Earth. The Ringed Planet spends the balance of 1996 in Pisces, southeast of the Circlet, a five-star asterism.

Speaking of Saturn, why not try out the Saturn Nebula in neighboring Aquarius?

Otherwise known as NGC 7009, this 8th-magnitude planetary nebula gets its moniker from a resemblance to the Ringed Planet when seen through large telescopes. Find it 1.8° northeast of M73, a tiny, telescopic grouping of four stars. Also nearby is the globular star cluster M72.

If you're under a very dark sky, try for the Helix Nebula, the nearest planetary nebula to the solar system. Despite the fact it occupies an area half the apparent size of our Moon, a low surface brightness means you will need binoculars to find it.

Locate its position in Southern Aquarius, and then move your eyes slowly around the field of view.

The nebula's faint outline will reveal itself through this averted vision technique. Consult last month's Almanac for more information about the Helix.

Before too much time passes after sunset, check in on **Comet Hale-Bopp**. How bright does it look to you? Will next spring's spectacular comet keep up with or surpass published predictions? Follow it all this month through binoculars.

Early in November Hale-Bopp creeps up on M14, a fine globular cluster in Ophiuchus.

The comet continues northeast for the rest of the month, passing south of NGC 6535 by November 30. Expect it to be an easy 5th-magnitude or brighter object. This brightness is remarkable, considering the comet is over 400 million kilometers from Earth.

Throughout November we look back at the comet toward the Sun's general direction along our own planet's orbit. During this time our Sun moves east into Libra as we move in our orbit around it.

If we orbited in a circular path, the Sun would appear to move through our sky at a constant speed.

But because Earth moves in an elliptical orbit, which causes it to speed up and slow down, the Sun's apparent motion moves faster and slower than its average speed, depending on where we are in our orbit.

The difference in time between when our Sun lies due south and when the imaginary "mean" Sun that travels at a constant speed reaches reaches the same point is called the "Equation of Time."

On November 2 this value reaches a maximum for 1996 of 16 minutes 26 seconds. We say the Sun is "running fast" because it reaches the meridian just over 16 minutes before where the Sun would be if Earth traveled in a circular orbit.

By late evening, when the mental gymnastics of reconciling real and mean Suns is just a distant memory, scan overhead with binoculars. There you'll find Andromeda and the realm of nearby galaxies.

The most obvious one is the Great Spiral Galaxy in Andromeda, M31. Its fuzzy-looking light has been traveling towards Earth for a staggering 2.2 million years.

A telescope reveals two companion galaxies, the equivalent to our own Milky Way's Magellanic Clouds. M32 is the brighter of the two and lies a half degree south of M31's center. A degree northwest is NGC 205, a fainter but larger galaxy than M32.

Travel southeast of Beta (β) Andromedae the same distance that star is from M31 to find M33, the Pinwheel Galaxy in Triangulum.

Its face-on form covers an area of sky larger than the full Moon and shines across 3.6 million light-years of space. It and M31 are part of what's called the Local Group of Galaxies, a group that includes our own Milky Way.

You'll need a telescope with an 8-inch or larger mirror to pick out this giant's spiral arms. In them are bright knots of star forming regions, similar to our own galaxy's Orion Nebula. (See this month's Observer's Challenge.)

You will have to wait until after midnight to catch the next planet. **Mars** rises with Leo, beginning the month less than 2° east-northeast of Regulus.

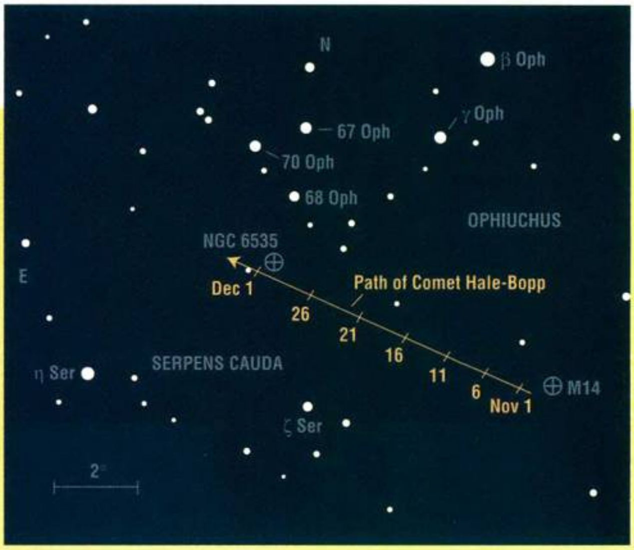
The Red Planet's orange glow contrasts nicely with the electric blue-white Regulus. The two are of similar brightness, Mars being fractionally brighter at magnitude 1.1. Which looks brighter to you?

Mars' easterly path takes it 1 ½° south of the galaxies M95 and M96 between November 14 and 17. Though the planet is not much to look at through a telescope during November, its 6"-diameter disk will grow slowly as the planet approaches a March 17 opposition.

Venus rises three to four hours after Mars, a glowing sparkler in contrast to fainter Mars. It is orbiting ahead of Earth on a faster, inner orbit, moving to the far side of the Sun.

Hot On Hale-Bopp

James R. Foster (July 21, 1996)



ASTRONOMY: Elisabeth Rowan

Excitement continues to build as Hale-Bopp grows ever brighter. There's plenty of time this fall to follow this 5th-magnitude fuzzball through the evening sky as the sky darkens earlier each night, which partly compensates for the comet setting earlier.

At the start of November, Hale-Bopp is one binocular field south of Beta (β) Ophiuchi. Another landmark, the globular cluster M14, lies a bit more than one lunar diameter (30') west of Hale-Bopp.

Note the comet's and globular's fuzzy textures are not the same, nor is brighter Hale-Bopp perfectly round.

On November 19 and 20, the gradually brightening comet passes a 6.5 magnitude star. By the end of the month, 5th-magnitude Hale-Bopp scoots less than a lunar diameter south of the diminutive globular cluster NGC 6535. You'll need at least an 8-inch telescope to get a look at this magnitude-10.6 deep-sky target that measures a mere 3.6' across.

The Moon begins to interfere after mid-month, but once again leaves us in darkness after the 26th. Although you will be able to spy Hale-Bopp from the city or in moonlight, country skies let you witness its growing tail. — *A. L.*

November's Asteroid Offering

November offers backyard observers the opportunity to nab a couple of relatively high-numbered asteroids.

The higher designation numbers mean 511 Davida and 704 Interamnia were only discovered relatively recently, due to their distance and dark nature. Davida was discovered in 1903; Interamnia, 1910.

Both asteroids lie near perihelion, their closest point to the Sun, and hence appear brightest (near magnitude 10) in our night sky. They are also at opposition — in line with the Sun and Earth — so this is about as close to our planet as they get.

Even though the pair come to opposition two more times before the end of this century, they will shine 1.5 magnitudes *fainter* than their current apparition.

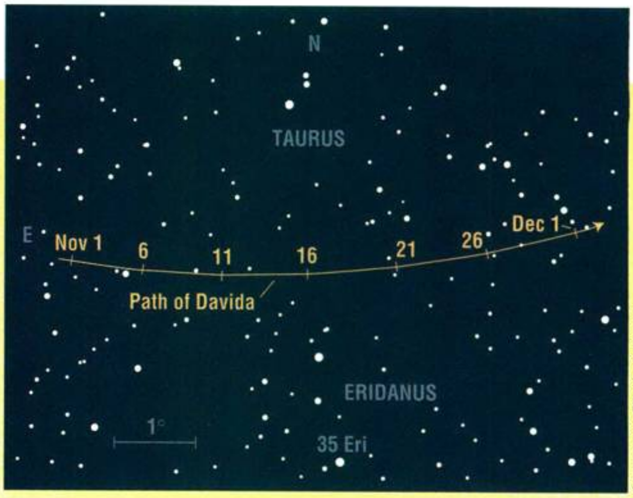
Davida ambles across southern Taurus, skipping a few arcminutes north of a 7.5-magnitude star on the evening of November 5.

Although this area of sky has no star clusters or galaxies, the Milky Way's dusty clouds leave their signature on the starfields; as you sweep the area the number of stars jumps and falls.

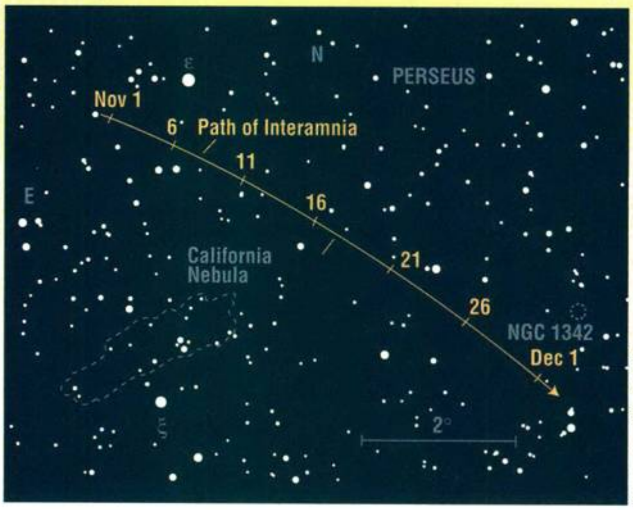
Meanwhile 704 Interamnia starts off 2° north of the California Nebula in Perseus and ends the month 1.3° southeast of the star cluster NGC 1342.

Make a drawing of the same field over two nights to detect the movement of the faint interlopers.

Davida and Interamnia each measure about 330 km (200 miles) across and have reflectivites roughly half that of our Moon, meaning they are fairly dark bodies. — *A. L.*



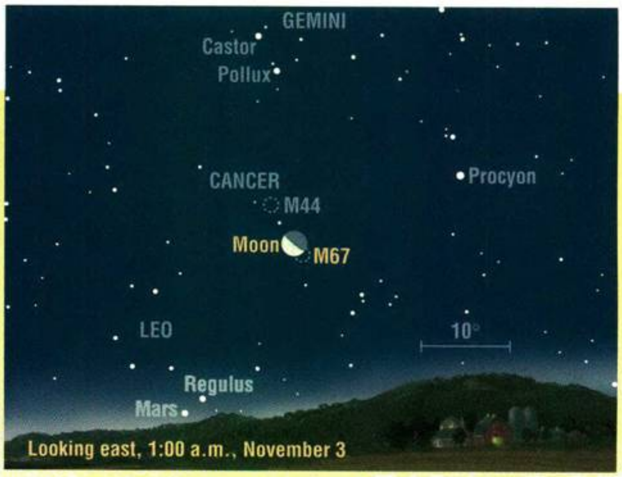
ASTRONOMY: Elisabeth Rowan



ASTRONOMY: Elisabeth Rowan

Luna and a Distant Star Cluster

David Ratledge



Looking east, 1:00 a.m., November 3

ASTRONOMY: Elisabeth Rowan

If you're out observing on November 2/3, don't shut down at 11 p.m. when the Moon rises. The bright and compact star cluster M67 lies only one and a half lunar diameters from the southern edge of a third quarter Moon.

Because many of M67's stars are relatively bright — in the 10th magnitude range — light from the nearby Moon should not seriously affect their visibility.

Still, you'll want to use moderately high power to get a close-up view of this old star cluster. M67 may be as much as two thirds the age of our universe.

Turning to the Moon, check out the Straight Wall region, about 1⁄3 the Moon's diameter from its south end.

Instead of looking like the dark-line feature of first quarter (see September's "Pull An All-nighter" Almanac project box), it appears as a white line that marks the wall's *brightly lit*, sunward-sloping face. — *A. L.*

This means that we are seeing a greater percentage of illumination on the planet. A telescope easily shows its gibbous phase.

Its –4.0-magnitude disk may be too dazzling to look at in the eyepiece, but as twilight encroaches its phase will become easier to see.

Block out some predawn observing time later in November for the Leonid meteor shower. Although its peak occurs on November 17 during midmorning for North American observers, monitor the early morning hours of the 17th for significant activity.

The return of the shower's parent comet in 1998 might give rise to heightened activity, perhaps culminating in a meteor storm.

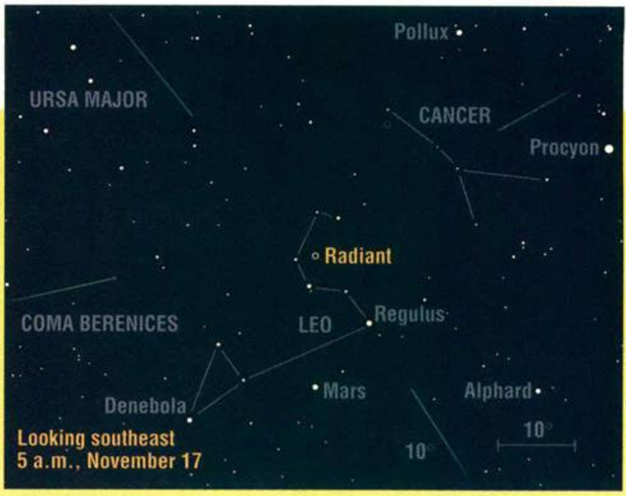
The last storm occurred in 1966; another might happen sometime during the next three years. Tantalizingly, an increase in Leonid activity has been logged in recent years. The waxing Moon sets by the time Leo's Sickle, the shower's radiant, rises.

Two solar system members miss out on the Leonid spritzing. **Pluto** is lost in the Sun's glare, passing through conjunction on November 24/25. **Mercury** also passes around the Sun's far side this month.

This superior conjunction occurs on November 1/2, after which Mercury makes its way to an early December evening apparition, best seen from southern climes. ☐

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist for Environment Canada in Alberta.

Thanksgiving's Leonid Meteors



Looking southeast
5 a.m., November 17

ASTRONOMY: Elisabeth Rowan

Meteor observers have good reason to give thanks for the Leonid meteor shower. Activity levels are indeed ramping up towards what might be a meteor storm in 1998.

Such a burst often happens every 33 years as the shower's parent comet passes through the inner solar system. Back in 1966 thousands of meteors per minute streamed from Leo's Sickle for a total of 20 minutes.

Meteors occur when comet dust burns up in Earth's atmosphere. The closer we are to a comet's path the more debris we intercept. This year we are closer than we've been for 30 years.

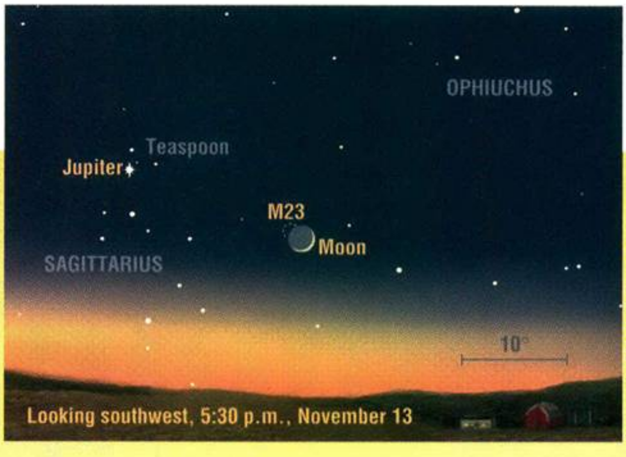
Under a dark sky after midnight on the night of November 16/17, once the first quarter Moon sets and the Sickle of Leo rides high in the sky, look for more than 60 speeding meteors per hour. Such a number even rivals the perennial August Perseid shower.

Some predictions place the shower's maximum at midmorning on November 17; others vary up to 7 hours. Ride lady luck if you want to catch a high-intensity burst.

As with any meteor shower expedition, arm yourself with a lawn chair, sleeping bag, and a hot drink.

Have some binoculars handy to scrutinize any trails brighter Leonids may leave. If you want to be scientific about your observations, log your meteor counts at 10-minute intervals and let ASTRONOMY know your results. — *A. L.*

An Archer's Crescent Encounter



Looking southwest, 5:30 p.m., November 13

ASTRONOMY: Elisabeth Rowan

The Moon speeds around the Earth at a rate of about 1 km per second (5⁄8 mile per second), much faster than any arrow from a human's bow.

But in Greek mythology, Sagittarius was a fiendish archer; maybe his arrows could catch the Moon. Such a moving mark lies in the slender, 36-hour-old crescent Moon that greets evening twilight on November 12.

One target on the Moon's path is the star cluster M23. East-coasters can watch the crescent Moon approach M23 on the evening of November 13, but only observers on the west coast will see Luna pierce the cluster's heart.

Abundant earthshine should let observers watch the Moon's gray limb cover M23 one star at a time.

The next night, viewers armed with binoculars will see Jupiter to the left of the thicker crescent Moon. Look nearby for a pretty asterism in Sagittarius called the Teaspoon.

It might look like the Archer's helmet plume, but modern stargazers all agree this asterism seems most appropriate, considering Sagittarius' teapot shape. — *A. L.*

A Deep-Sky Romp Through Fall Skies

Globular Cluster M30
Bill Iburg

The faint star patterns of autumn harbor many deep-sky wonders.

by Dan Koehler

Autumn is a transitional time of year. Summer's heat slowly yields to a winter's chill, while all the richness of life hunkers down for leaner times.

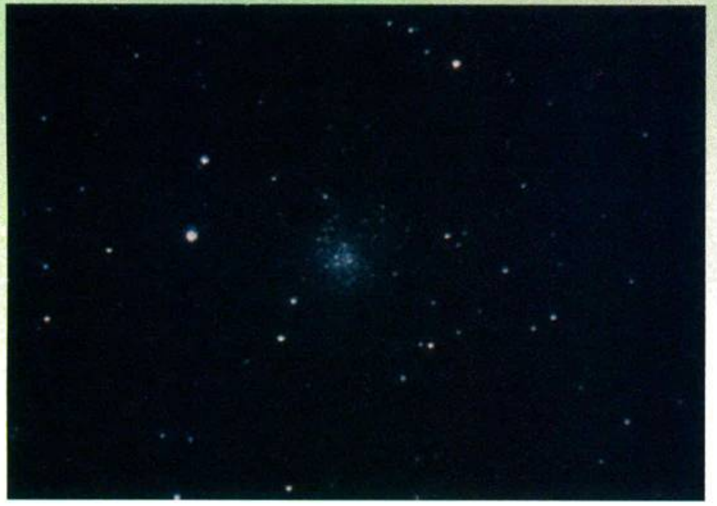
This time of change extends into the heavens as well. Summer's splashy Milky Way hands off to fall's subdued constellations. A smattering of deep-sky targets lie in these demure skies, some easy, others challenging, all covering a wide array of types.

So rather than put away your scope for the winter, haul it out for a fall star tour that starts on the heels of summer and moves to the edge of winter.

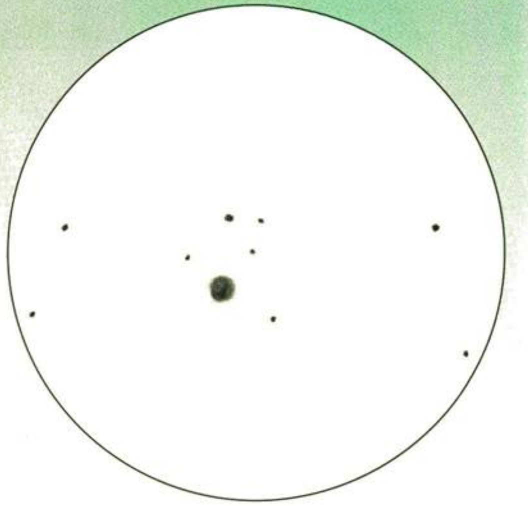
We begin the tour in an area of sky completely devoid of other deep sky objects. The globular star cluster **M30** (NGC 7099; 21h40.4m, –23°11') shines at magnitude 7.5 and measures 11' across, a little less than half the size of M13, the Hercules Cluster. It is an easy object in small telescopes and binoculars and lies less than ½° slightly northwest of the 5th-magnitude double star 41 Capricorni.

M30 is one of 18th-century Charles Messier's original objects,

Globular Cluster M72



Jack Newton
(16-inch f/5, Ektachrome 400, 15 minutes)



Randy Lutz
(6-inch f/8 Newtonian, 60x)

first glimpsed by the comet hunter in August 1764. It lies some 40,000 light years from us and spans about 100 light-years. Through a 10-inch or larger telescope, this cluster sports a distinctive hooked shape and a V-shaped void that points to a tight, bright nucleus. Telescopes with apertures 6 inches or less probably won't resolve the core into individual stars, even at high power.

Globular clusters are ancient, dense spheres of stars, some of which are at least 12 billions years old. About 130 are visible to Northern and Southern Hemisphere astronomers, distributed in a halo surrounding the central bulge of our Galaxy. Judging by the number of globular clusters we see surrounding other spiral galaxies, the Milky Way may be encircled by up to 1,000 of these star clusters.

After taking in M30's distant glow, let's reverse course about 20° to the west and move another 8° north to view the first of three closely spaced objects in western Aquarius.

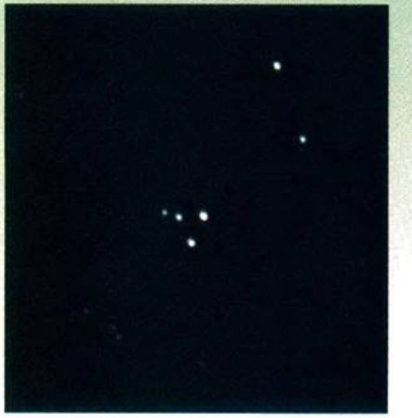
M72 (NGC 6981; 20h53.5m, –12°32') is another globular cluster, but about half the size of M30, which is not surprising when you consider it lies 20 percent more distant, at 60,000 light-years. This is also a fainter cluster, at magnitude 9.4, and is difficult to resolve into individual stars with a small telescope. Some mottled detail has been reported around the edges of M72 in moderate-sized instruments — otherwise it is featureless. Scopes larger than 10 inches start to resolve a scattering of member stars.

Tiny M72 was first seen by a colleague of Messier's in August 1780. Messier confirmed and added the object to his catalog of comet lookalikes in October of that year.

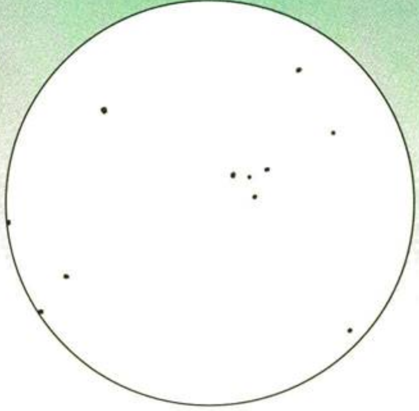
Messier, however, made a few mistakes in his observations, and **M73** (NGC 6994; 20h59.0m, –12°38') is one of them. The famed French comet hunter probably thought he was viewing a small open cluster when he described M73 as "three or four small stars which look like a nebula at first sight" that contained "a little nebulosity."

No photograph of M73 has ever revealed nebulosity about these stars. Messier's error was probably due to the small size of his optics, to poor seeing conditions at the

Star Cluster M73

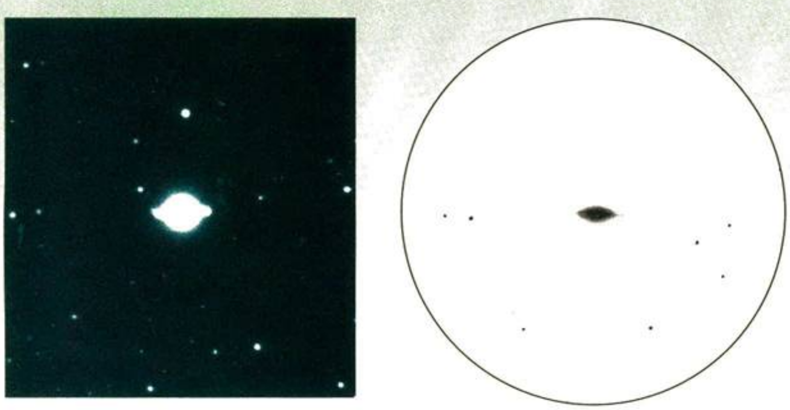


Chris Schur
(8-inch f/10 SCT, Kodak 103aF, 10 minutes)



A. J. Crayon
(8-inch f/6 Newtonian, 100x)

Planetary Nebula NGC 7009



Dale Mais
(14-inch f/7, Tech Pan film, 10 minutes)

Daniel Troiani
(17.5-inch f/4.5 Dobsonian, 300x)

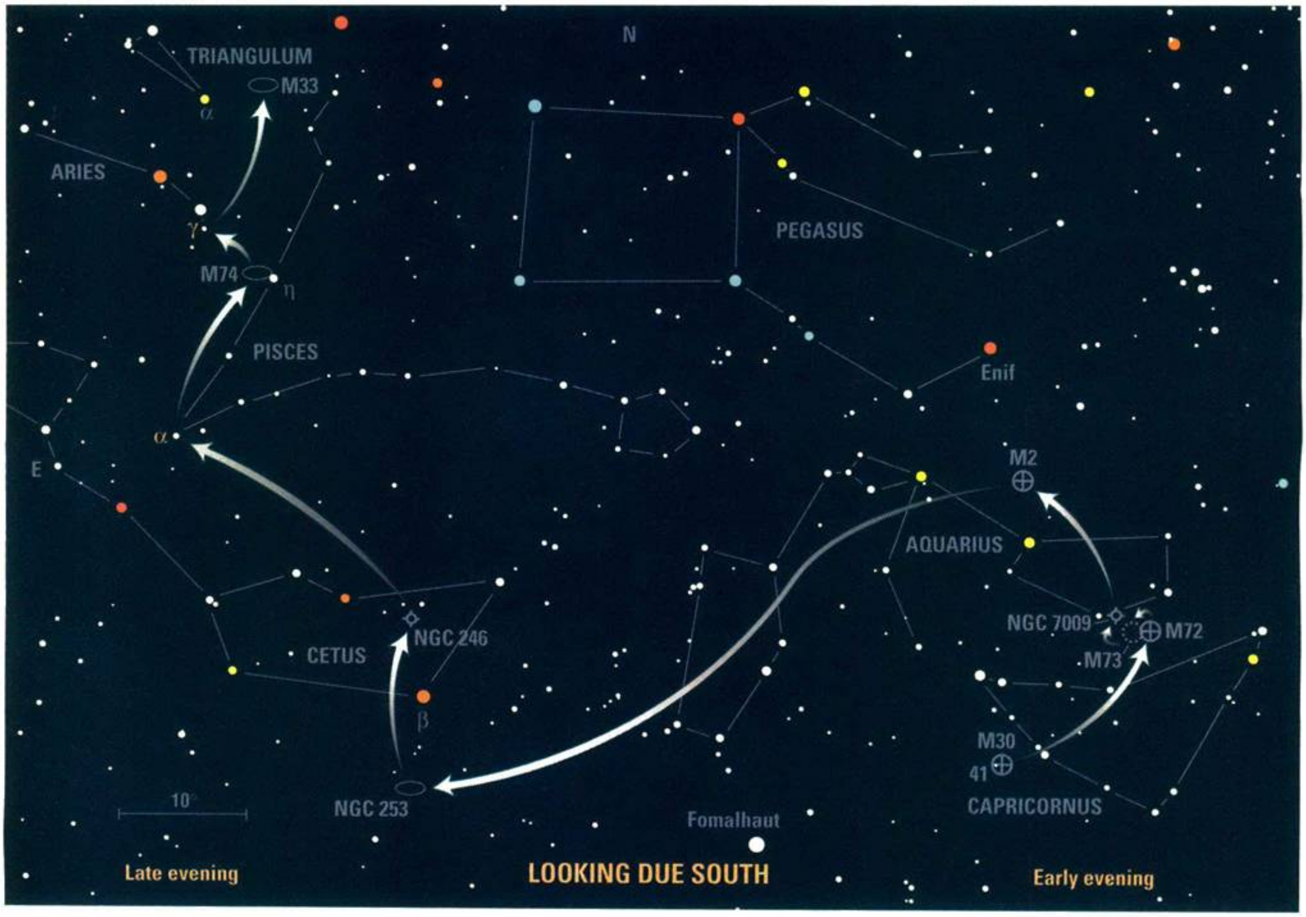
time he made his observations, or both. Scan at low power about 1.5° slightly south and east of M72 for this bogus deep-sky object composed of four faint stars.

Proceeding on our tour, we move 3° northeast to **NGC 7009** (20h 59.0m –12° 38'), the Saturn Nebula, so named by 19th-century deep-sky observer Lord Rosse for its resemblance to the ringed world of our solar system. This is the first planetary nebula observed by Rosse with his six-foot reflecting telescope in England.

The nebula has a photographic magnitude of 8.3, a high surface brightness, and a stellar appearance in small telescopes due to its small angular diameter of 25". A central, 12th-magnitude star is responsible for the nebula's illumination. The bluish star shines at a searing temperature of 55,000 °C. Ultraviolet radiation from this tiny star gives the Saturn Nebula a distinctly fluorescent greenish hue. NGC 7009 is about 3,900 light-years from us.

A 6- to 8-inch telescope working at high power (250x to 300x or so) begins to give a hint of the nebula's extended rays or "ansae" as Lord Rosse called them. You'll need a dark, steady, and transparent night to attempt this sight with a smaller telescope, however.

Tonight's last scheduled globular cluster also lies in Aquarius. At magnitude 6.5, **M2** (NGC 7089; 1h33.5m –00°49') is a fine example of this class of deep-sky object. This globular sits in a fairly empty patch of sky, and is easily glimpsed through even the smallest telescope. Messier himself recovered it in 1760, after its initial discovery 14 years earlier.


N
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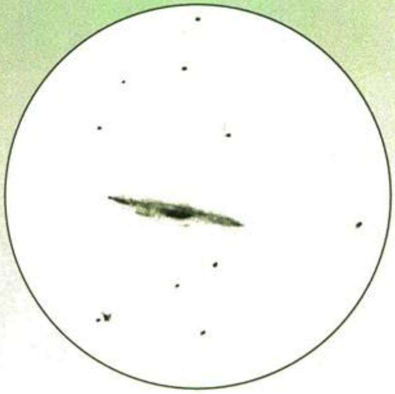
M2
AQUARIUS
CETUS
NGC 246
β
NGC 7009
M72
M73
M30
41
CAPRICORNUS
NGC 253
10°
Fomalhaut
Late evening
LOOKING DUE SOUTH
Early evening

Spiral Galaxy NGC 253 and NGC 288



Spiral Galaxy NGC 253
Alan Goldstein
(6-inch f/8 Newtonian, 60x)

NGC 253 (top) with NGC 288
Michael Stecker
(10-inch f/4.5, Fuji HG400, 30 minutes)

M2's pronounced round shape hints that few of its 100,000 individual stellar members lie outside of a very concentrated nucleus. The cluster's 50,000 light-years distance shrinks its 150 light-year diameter to an apparent size of 13'.

We now leave Aquarius and enter the constellation Sculptor. Pan south and east to a point 7° due south of the bright star Beta (β) Ceti. There you'll come across a gem of a spiral galaxy, **NGC 253** (00h47.5m, –25°18'). NGC 253 is an easy object for 6- or 8-inch telescopes, and, at magnitude 7.1, it is readily visible in binoculars, too. Owing to its very southerly declination, however, northern viewers should wait until it is near the meridian and at greatest altitude above the southern horizon for best views of the spiral.

NGC 253 is one of six prominent galaxies in the Sculptor Group of galaxies, also known as the South Galactic Pole Group. At about 10 million light-years away, these galaxies form the nearest cloud of galaxies to our own Milky Way Local Group.

NGC 253 is a dusty galaxy. Even a small telescope at moderate power might pick up some of the mottling effect this dust produces. The galaxy spans 25' by 7', and appears tilted to our line of sight a mere 12° from edge-on.

While in the neighborhood, sweep slightly south and east to pick up NGC 288, a nice 8th-magnitude globular cluster. About a degree below it lies the direction of the Milky Way's south pole.

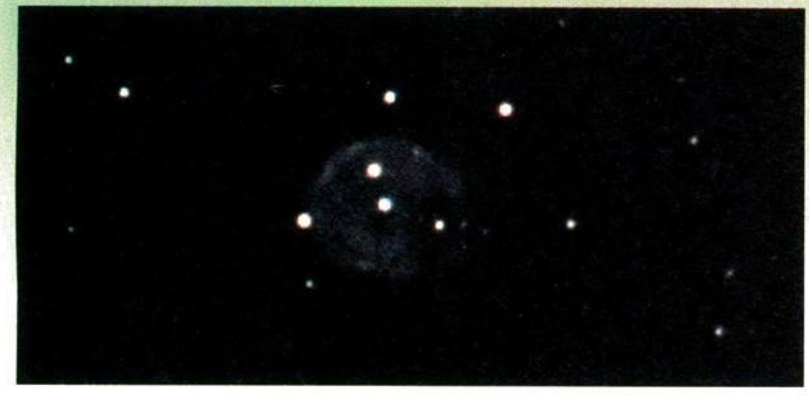
Now shift about 7° straight north of NGC 253 past the bright star Beta (β) Ceti to run into the large planetary nebula **NGC 246** (00h47.2m, –12°09').

At magnitude 8.0 and 225" in diameter, the nebula bears more than just a passing resemblance to its famous cousin, the Owl Nebula (M97), in Ursa Major. Sharp photos of NGC 246 reveal an eerie, human skull-like appearance.

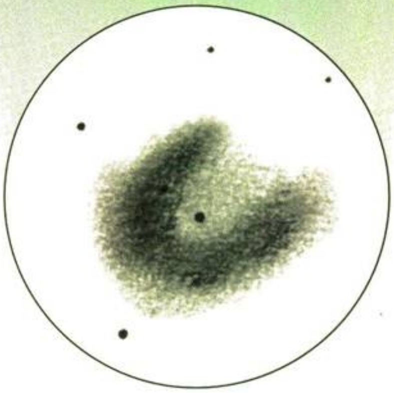
NGC 246 is best viewed in a dark, transparent sky, at low power. Another target of opportunity, the small spiral galaxy NGC 255, lies about 15' to the northeast.

Let's move onward and upward — about 15° straight east and about 12° due north to a star that binds the two fish of Pisces together. Alpha (α) Piscium (02h02.0m, 2°46') is a well-known

Planetary Nebula NGC 246



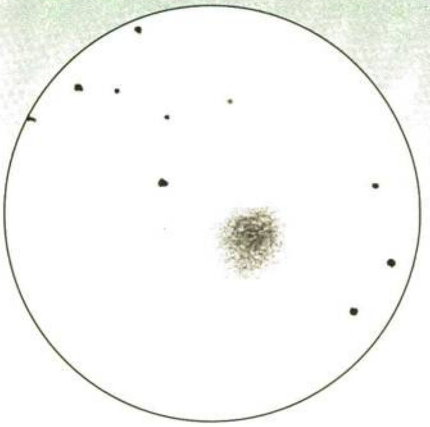
Luke Dodd
(4.7-inch f/8.5, Fuji 400, 120 minutes)



Chuck Coates
(12.5-inch f/5 Newtonian, 160x)

Spiral Galaxy M74

Bill Iburg
(14-inch f/5.5 SCT, Ektachrome 400, 40 minutes)



Rick Hunter
(14-inch f/10 SCT, 100x)

double star of peculiar color contrast, described by numerous observers as greenish white and blue, pale yellow and brownish yellow, pale yellow and fawn, and pale green and blue.

Alpha B (magnitude 5.1) takes about 720 years to move about Alpha A (magnitude 4.2) in a highly eccentric orbit. The two stars will appear closest to each other in 2060. Presently, a 2.9" gap of sky separates the pair.

From Alpha Piscium, move up the eastern "cord" of Pisces, along a row of evenly spaced bright stars, past Omicron to Eta. About 1½° northeast of Eta you'll find a fine face-on spiral galaxy, **M74** (NGC 628; 01h36.7m, 15°47').

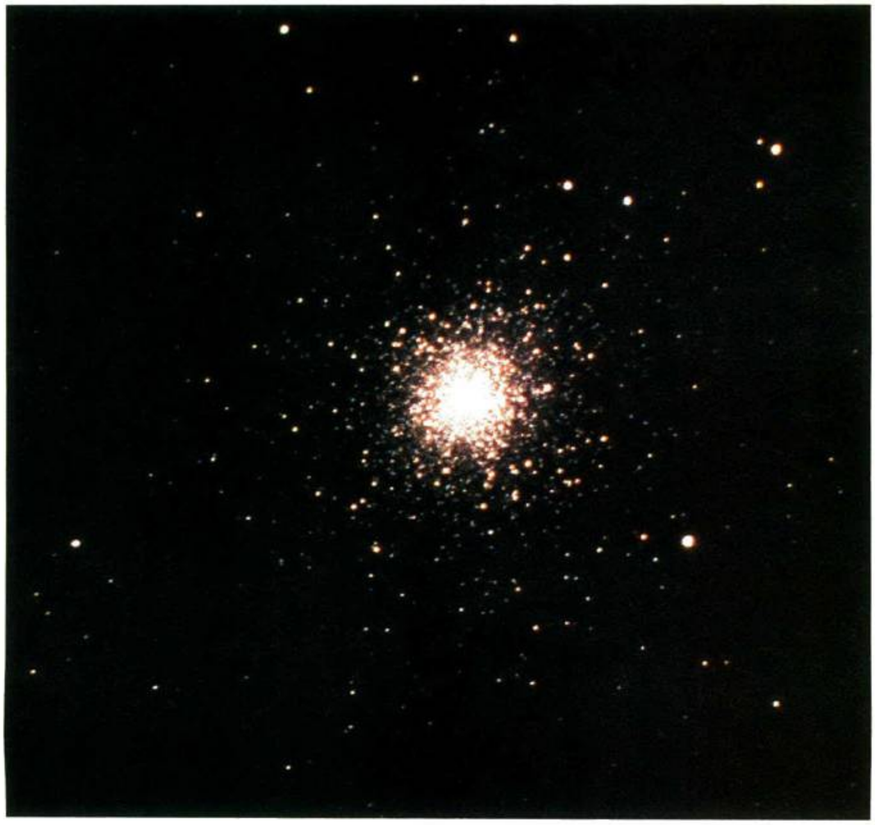
Magnitude 11.2 M74 is a dim object best viewed at low power. A 6- to 8-inch telescope just begins to give a hint of the galaxy's spiral nature. Try observing under the clearest, darkest skies possible, and when the galaxy is overhead.

Long-exposure photographs disclose spiral arms composed of clumps of dust, gas, and stars. M74's fairly bright nucleus should appear in even a small telescope.

Larger apertures show a nucleus surrounded by faint, diffuse, but discernible spiral structure. M74's distance from us is about 35 million light-years; its diameter, 80,000 light-years.

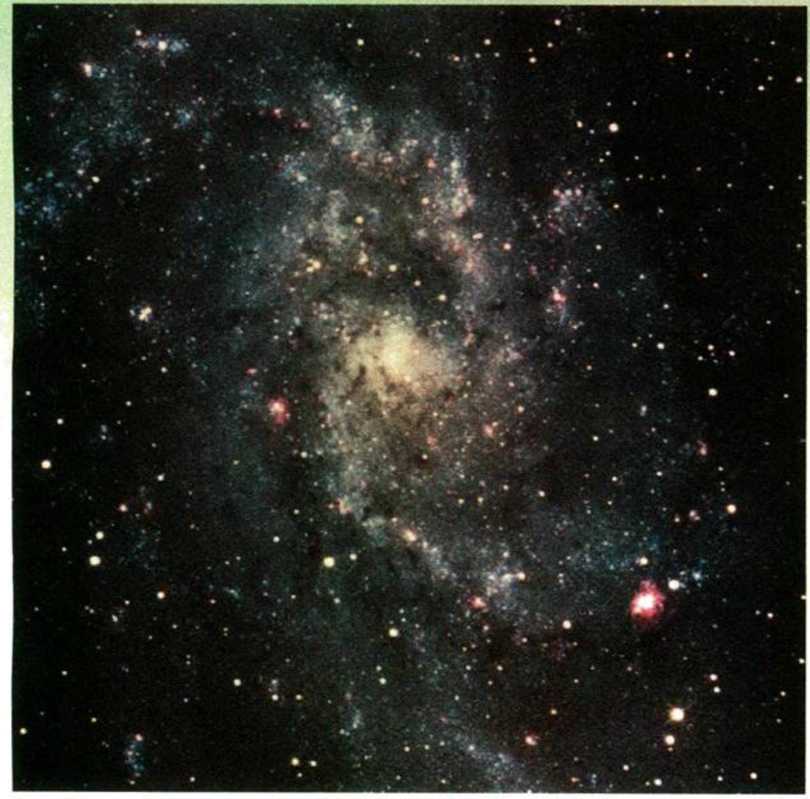
Move your scope about 5° east and 3° northward to one of the Milky Way's better known double stars, **Gamma (γ) Arietis** (01h 53.5m, 19°18'). Gamma's two components shine white at the same magnitude, 4.8, separated by 7.8". The duo lies about 160 light-years from us, orbiting each other at a separation distance of 385 AU. While in the area, look slightly to the southeast of Gamma for the spiral galaxy NGC 772.

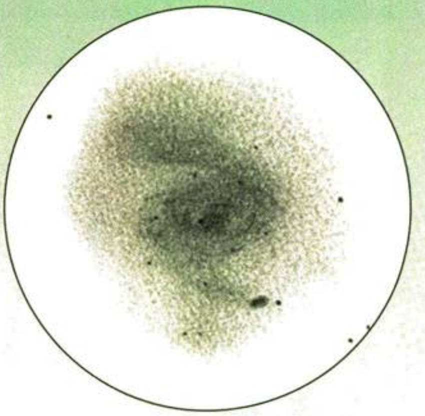
Leave Aries now and move into the constellation of Triangulum to find **M33** (NGC 598; 01h 33.8m, 30°39'), also known as the Pinwheel Galaxy. Center on it by panning west from Gamma Arietis about 7° and then 10° north. The



Globular Cluster M2
Kim Zussman
(11-inch f/10, Fujichrome 400, 30 minutes)

Spiral Galaxy M33





Jeff Corder
(8-inch f/10 SCT, 70x)

Tony Hallas
(12.5-inch f/7, Fujichrome 400, 45 minutes)

Pinwheel lies about 5° slightly northwest of Alpha (α) Trianguli.

While M33 is a well-known photographic object, it is one of amateur astronomy's greatest telescopic challenges. Ironically, because of its huge size — 62' by 39' — and low surface brightness, the best views are in 7x50 binoculars. A visual magnitude of 5.7 makes it visible to the naked eye under dark, transparent skies.

If you view it with a small telescope, use low power and look carefully. It's possible to miss M33, even when its centered in the eyepiece. Pan slowly across the galaxy's field, keeping an eye out for any brightening in the sky background. Once you've centered the glow, apply slightly higher power to improve the contrast.

You should notice a relatively bright central area and some clumpiness in the outer arms. These clumps are regions of star formation with glowing gas clouds not unlike the Orion Nebula. Some of these bright, so-called H II regions have separate entries in the deep-sky NGC catalog.

As with any deep-sky object, let M33 climb high in a dark sky for the best view. This happens close to meridian, which means overhead in M33's case for most observers in North America.

The Pinwheel is the second closest spiral to our Milky Way, after M31 in Andromeda, at a distance of about 2.4 million light-years. M33 and M31 are about 570,000 light-years apart and therefore four times closer to each other than either is to our Galaxy. Because M33 is populated by B-type supergiant stars, color photographs of it appear much bluer than most spiral galaxies.

M33 comes alive with a large scope. In a 16-incher at low power the whole field of view appears aglow with a soft gray-green light. Sharp-eyed observers will see a tiny, almost stellar nucleus surrounded by a glowing hub. Around the galaxy's center, the soft glow of the spiral arms is peppered with very faint, tiny glows. These are the H II regions and associations of O and B stars, giant islands of newborn suns. One of the galaxy's spiral arms hosts NGC 604, a huge gas cloud that is the largest emission nebula known. Seeing this distant factory where infant stars are coalescing from thick clouds of dust makes viewing M33 a treat.

After soaking up M33's soft light, you might notice constellations like Auriga, Taurus, and Orion are starting their climb into the sky. Autumn's subtleties are getting edged out by the winter's brighter stars. But for one night, you've given soft-spoken Capricornus, Pisces, and Triangulum their say before seasonal banishment. Prior to winter's victory, pull out an atlas like *Sky Atlas 2000.0* or *Uranometria 2000.0* and plan your own deep-sky romp before the snow flies.

After all, one fall starhop deserves another! ☐

Wisconsin deep-sky observer Dan Koehler (dkoehler@astronomy.com) is advertising sales manager for ASTRONOMY.

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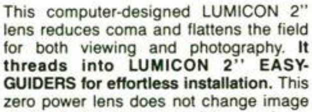

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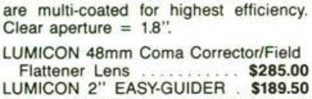

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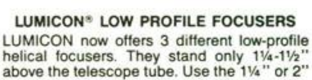

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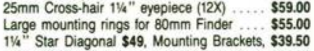

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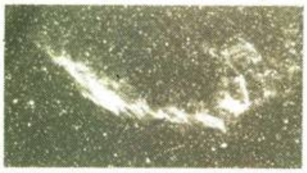

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This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

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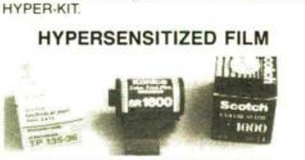

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Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

It's Hip to be Square

The Great Square of Pegasus highlights one of the most magnificent areas of the autumn sky.

by David J. Eicher

When it comes to the autumn sky, squares are in. Particularly when the square is the central, bright fixture of Pegasus the Winged Horse, the so-called Great Square. Consisting of Markab (Alpha [α] Pegasi), Scheat (Beta [β] Pegasi), Algenib (Gamma [γ] Pegasi), and Alpheratz (Alpha Andromedae), the Square is the dominant feature of the evening sky in November, situated high over the eastern horizon. This stately form covers 18° by 14° of sky — it's not exactly square — and makes a marvelous naked-eye group of stars and serves as a jumping-off point for exploring the rest of Pegasus. It also holds secrets, including a myriad of galaxies that can be explored with a telescope.

Scheat marks the northwestern (upper right) corner of the Square. It is a variable star that usually hovers at magnitude 2.5, has a ruddy color, and lies 210 light-years away. Dropping south brings Markab into view. This white star glows at magnitude 2.5 and lies at a distance of about 110 light-years. Moving east, to the southeastern corner of the Square, locates Algenib. This bluish-white star shines at magnitude 2.8 and lies at the considerable distance of 570 light-years. Finally, marking the northeastern corner of the Square, is Alpheratz. Shining at magnitude 2.1, this white star lies only about 100 light-years away.

Mythologically, the Winged Horse represents the creature which the hero Bellerophon rode during his journey to slay Chimaera, a fire-breathing, lion/serpent/goat. The horse, as we normally view Pegasus, is upside-down: the Square represents its body and two lanes of bright stars stretching westward form legs and the horse's neck and head. The fore legs are represented by Eta (η), Delta (δ), Iota (ι), Pi (π), and Kappa (κ) Pegasi. The front quarter and head of the horse is marked by Xi (χ), Zeta (ζ), Theta (θ), and Epsilon (ε) Pegasi. This last star, called Enif ("the nose"), is a magnitude 2.3 orange star lying 780 light-years distant. About 4° northwest of Enif lies the bright globular star

Luke Dodd

cluster M15 (NGC 7078), a treat in binoculars and small telescopes.

Still deeper treasures lie scattered about the region. Northeast of Alpheratz is the brightest spiral galaxy in the sky, the Andromeda Galaxy (M31). At a distance of 2.2 million light-years, it is the most distant object visible to the naked eye. The galaxy glows at magnitude 3.5 and covers 3° by 1° of sky, giving it an elongated, ghostly appearance on dark nights. Another bright galaxy, NGC 7331, lies 4° north and slightly west of Eta Peg. A smattering of fainter galaxies, including the exotic, interacting group Stephan's Quintet, lie nearby. Inside and around the Square itself may be found a multitude of fine galaxies, including NGC 16, NGC 23, NGC 7448, NGC 7678, and NGC 7741.

Don't let autumn pass you by without exploring the region of the Great Square. At the very least, it would be truly unhip. □

David J. Eicher is Managing Editor of ASTRONOMY. *He has spent a prodigious number of hours scanning galaxies in the region of the Great Square.*

Exploring Cassiopeia's Bright Clusters

More than two dozen groups of stars as well as elusive nebulae await backyard telescopes in one of autumn's most spectacular constellations.

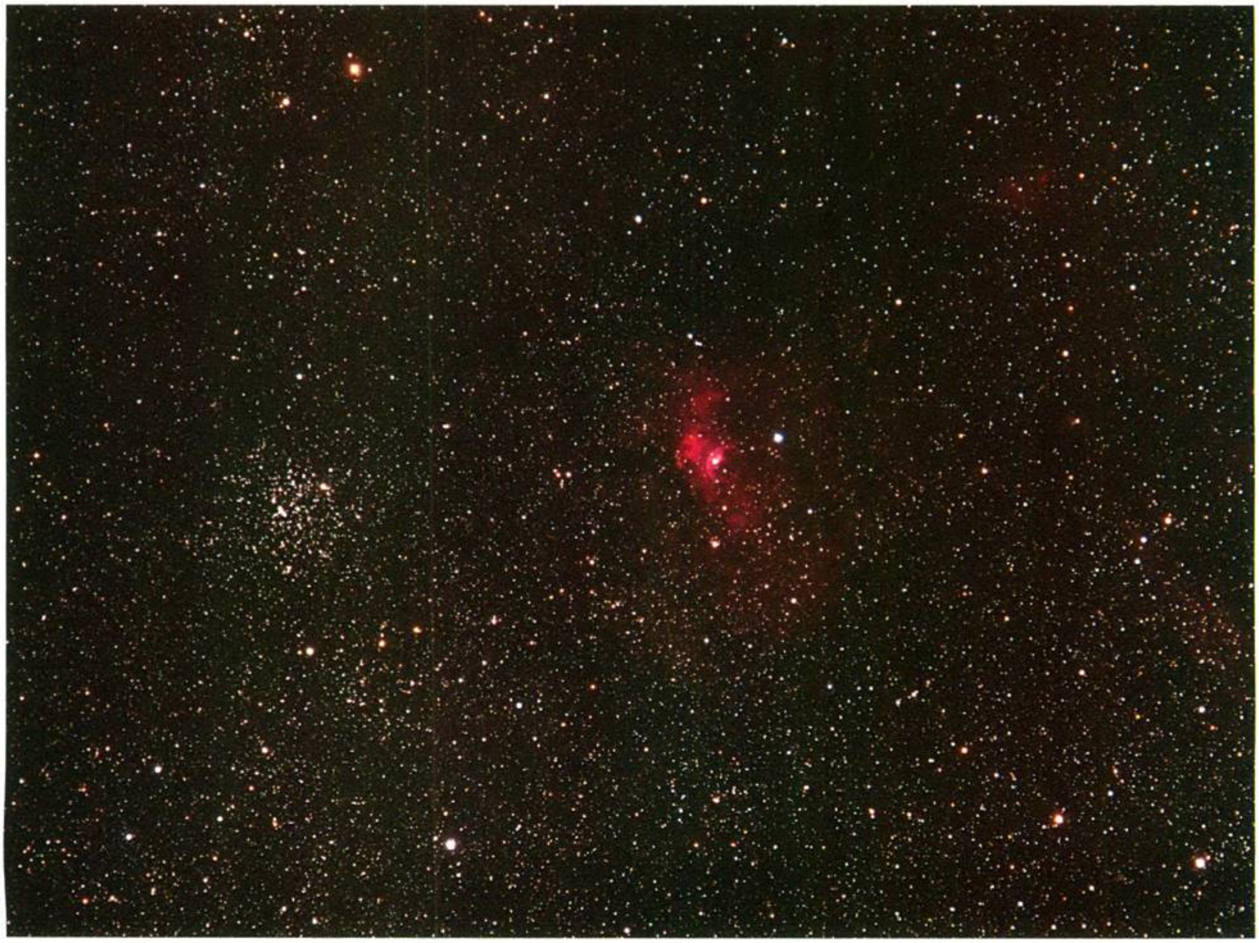
by Robert A. Garfinkle

It's instantly familiar on practically any clear night. The bright W-shape of Cassiopeia the Queen (or M-shape, depending on when you see it) consists of five bright naked-eye suns nearly 100 light-years away. Yet behind the naked-eye brilliance lurk more than two dozen bright star clusters and a selection of intriguing nebulae, each of which avails itself to binoculars and/or small telescopes. Many of these objects are visible at some time during any night of the year. Autumn, however, offers Cassiopeia to backyard observers at its best placement, inviting us to head out into the cool air and explore the vastness of this rich canvas of Milky Way.

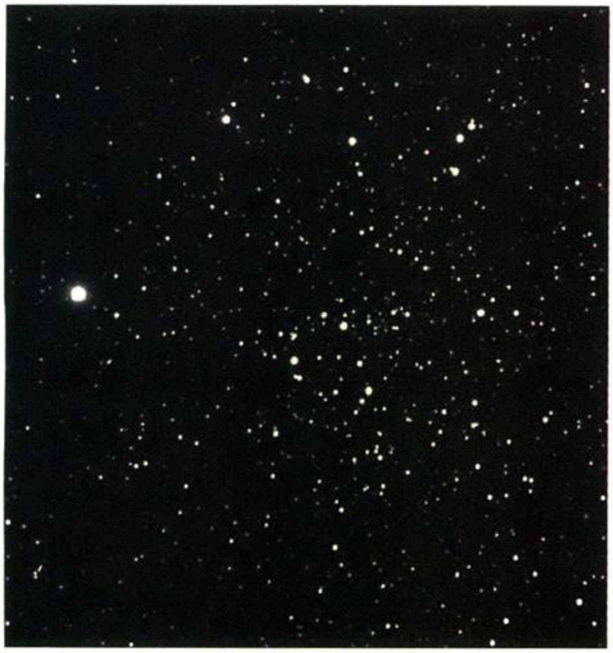
Use Binos and a Scope

Observe these clusters with both binoculars and a telescope if you have access to these instruments. Some of the clusters will be easier to see with binoculars than with a telescope, as the stars stand out from the haziness of the Milky Way. In a telescope, you'll get by with either a low-power (less than

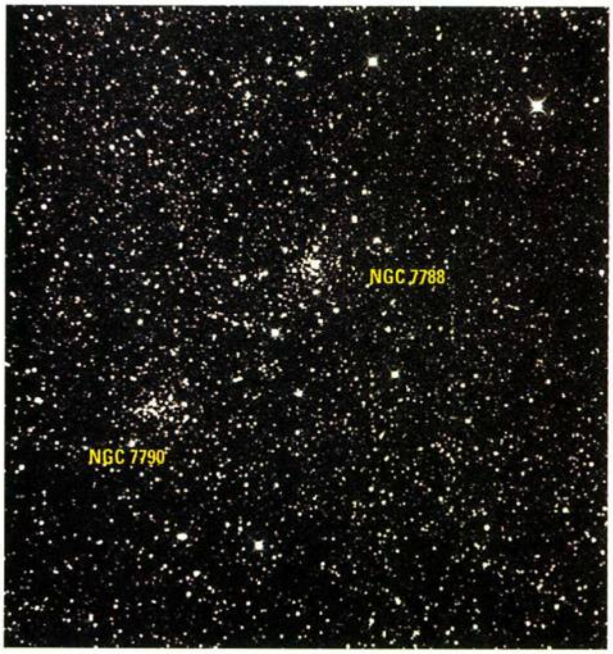
Cassiopeia's Milky Way holds a treasure chest of star clusters and nebulae. M52 glitters to the left (northeast) of the more elusive Bubble Nebula (NGC 7635).



Mark Park



Martin Germano



Lee C. Coombs

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NGC 129 (top left) marks the southern point of a triangle with NGC 136 and NGC 103. Northwest of Caph are NGC 7790 and NGC 7788 (top right), along with Harvard 21 (left). Another jewel in Cassiopeia's treasury is NGC 7789 (bottom). Use binoculars or a wide-field eyepiece for this beauty.

100x) or wide-field eyepiece for most of this star-hop. Which stars belong to a cluster and which are simply individual members of the rich Milky Way star fields surrounding the cluster? Determining this will sometimes challenge you. A simple classification system makes it easier to understand these differences. This system, developed in 1930 by the Swiss-American astronomer Robert J. Trumpler, is shown in the accompanying sidebar. Throughout this article, the Trumpler designation appears in parentheses following the object name, such as **M52** (I2r).

In most of the clusters, the individual stars are very faint, but when grouped together, their glow combines to make the cluster stand out. Imagine you are in a large ballroom at night and the only illumination is from a single one-watt light bulb at the far end of the room. The room is still dark. But turn on hundreds of one-watt bulbs and the room becomes brighter. For this reason a cluster appears much brighter than its component parts, even though the individual stars in the cluster are all much fainter than the listed magnitude for the cluster.

Start With Caph

This month in the evening sky, Cassiopeia appears as a flattened "W" in the northwest. On the right side of the "W" is Caph (Beta [β] Cassiopeiae). This magnitude 2.3 blue-white star lies about 30° south of Polaris (Alpha [α] Ursae Minoris).

When you aim binoculars at Caph, you'll see an arrow-like grouping of stars. The brightest star near the tip of the arrow is Caph. Forming the shaft of the arrow, which points away from Polaris, is a line of stars, most of

Trumpler Classification System for Open Clusters

Component 1: Concentration of cluster members

- I. Detached from surrounding star field with strong central concentration
- II. Detached with little central concentration
- III. Detached with no central concentration
- IV. Not well detached

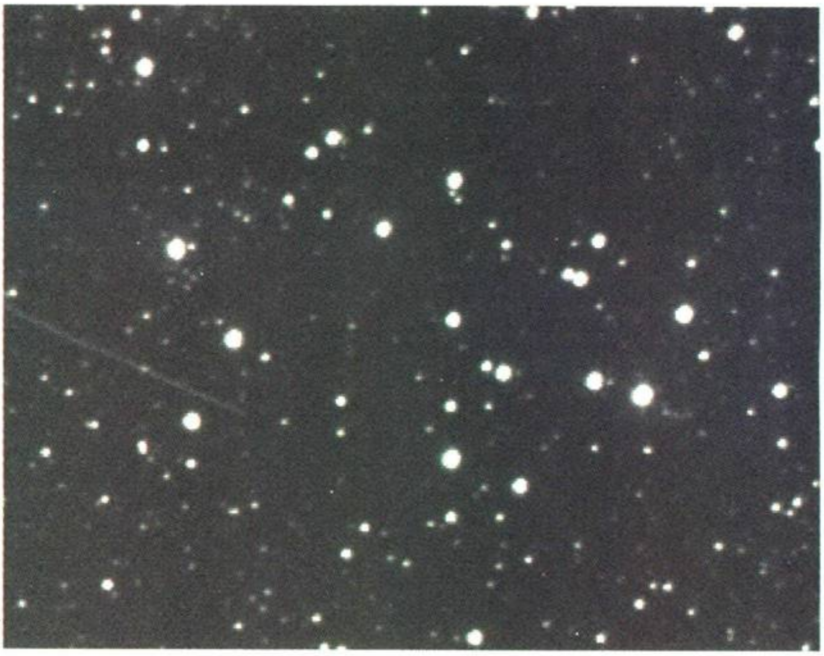
Component 2: Range in magnitude

1. Small range from brightest to faintest member
2. Moderate brightness range
3. Large range

Component 3: Richness

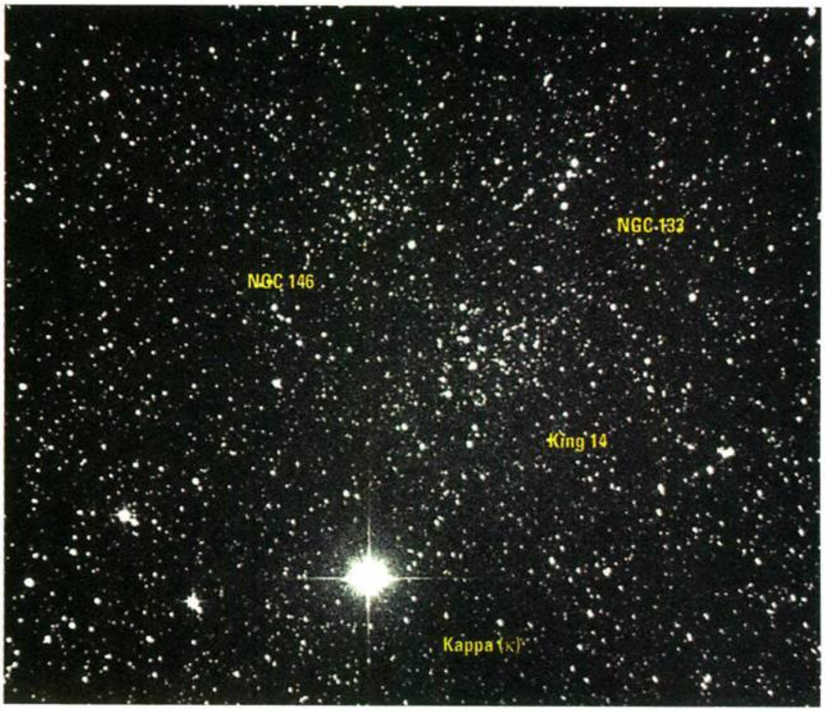
- **p** Poor, less than 50 stars
- **m** Medium rich, 50–100 stars
- **r** Rich, more than 100 stars

The components are put together such as I2p for open cluster NGC 7788 and shown in this article as NGC 7788 (I2p).



Gary Emerson

South of the giant star Kappa (κ) Cassiopeiae lies NGC 225 (above), a loose cluster that can be seen with binoculars. Note the meteor captured on the left side of the image. North of and observable within the same field of view as 4.2 magnitude Kappa are King 14, NGC 146, and NGC 133 (below).



Lee C. Coombs

which are doubles. Caph, located about 46 light-years away, is a pulsating, Delta Scuti-type variable star and also a double star. Caph fluctuates from magnitude 2.25 to 2.31 in about two-and-a-half hours. Its companion star has an orbital period of about 27 days.

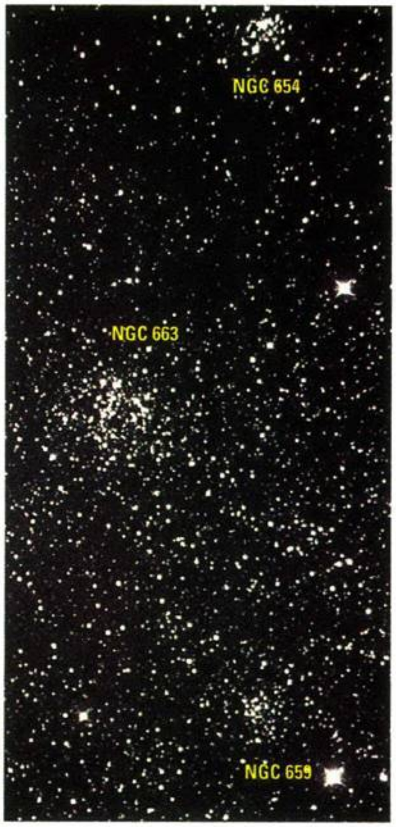
Aim your optical aide slightly northwest of Caph, placing the bright star on the southern edge of your finder scope view. You should be able to see a grouping of three small open star clusters, **NGC 7788, NGC 7790,** and **Harvard 21**. NGC 7788 (I2p) is about 7,850 light-years away and appears as a hazy patch of light and 20 stars centered around a 9th-magnitude star. NGC 7790 (III2p) is also a hazy patch of light with 40 stars that make up a 13th-magnitude triangle about 10,400 light-years away. Harvard 21 (IV2p) contains six stars and is difficult to separate from the background stars, but try to find it as a test of your skills. The glow from the six stars of Harvard 21 is slightly brighter than the background field.

Look For the Glowing "V"

Two of the best galactic clusters in Cassiopeia are **M52** (NGC 7654) and **NGC 7789**. At magnitudes 6.9 and 6.7, these two jewels are just beyond the naked-eye range, but easy to locate in binoculars. Move your scope to center **NGC 7788** on the eastern edge of your finder scope. M52 (I2r) will be on the opposite (western) edge of the field. The 100 stars of M52 are tightly compressed and form an easy-to-locate glowing "V" filled with points of light. The cluster is about 5,200 light-years from us. The "V" and trail of stars south of M52 will point you in the direction of the open cluster NGC 7789 (II1r), the richest cluster in the area, with about 300 stars. Many of the stars in this cluster are red giants. This cluster fills an area of the sky almost as large as the Moon, so the best view is either in binoculars or a wide-field eyepiece. NGC 7789 is situated between the blue-white stars Rho (ρ) Cassiopeiae and Sigma (σ) Cassiopeiae.

Hop one finder scope diameter northeast to Caph and then one more past it to an area festooned with clusters. Forming a triangle pointing south are the clusters **NGC 103, NGC 136,** and **NGC 129.** Use a low-power eyepiece to view NGC 129 (IV2p), as it is spread out and consists of about 35 stars. South of it is a double star that appears brighter than any of the stars in NGC 129. At the northern apex of this triangle are two faint clusters. The cluster to the west is NGC 103 (II2p), and slightly northeast of NGC 103 lies NGC 136 (II2p). Both of these clusters are hard to locate because they are small, contain few stars, and are faint: magnitude 9.8 for NGC 103 and magnitude 11.3 for NGC 136.

Five clusters should fit within a finderscope field of view. NGC 654, NGC 663,and NGC 659 (right), lie slightly to the east of an imaginary line drawn between Delta (δ) and Epsilon (ε) Cassiopeiae, along with Trumpler 1 and M103, shown at bottom right.



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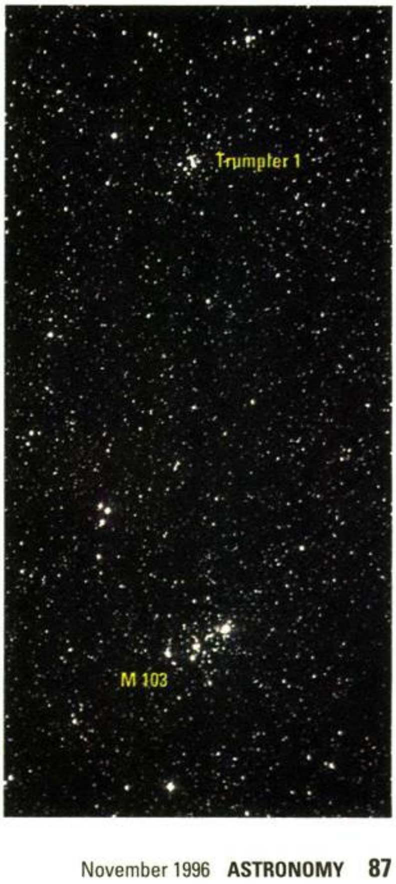


Martin Germano

Four Clusters In One Field?

Depending on the diameter of the field of view in your finder

Blue-white subgiant Gamma (γ) Cassiopeiae shown with nebulae IC 59 and IC 63 (above left and above right of Gamma, respectively). Remove Gamma from the field of view when observing these nebulae with a small telescope or binoculars; otherwise they will get lost in Gamma's glare.

J.C. Mirtle

scope, you may be able to place NGC 129 at the south edge of your field and have the tight grouping of **King 14, NGC 146,** and **NGC 133** on the northern edge. Included in your view will be the blue-white, magnitude 4.2, giant star Kappa (κ) Cassiopeiae.

Another field of view to the south lie **NGC 225, NGC 189,** and **Stock 24.** These clusters range in brightness from magnitude 7 through 9, and each is composed of faint stars. King 14 (III2p) contains about 20 stars and is faint at magnitude 8.5, while NGC 133 (IV1p) holds 5 stars spread out in a line about 7' long. East of NGC 133 is NGC 146 (IV3p), a cluster of 20 stars, that seems almost circular in shape with a "dark lane" running through its center. Nearby is NGC 225 (III1p), consisting of 15 stars.

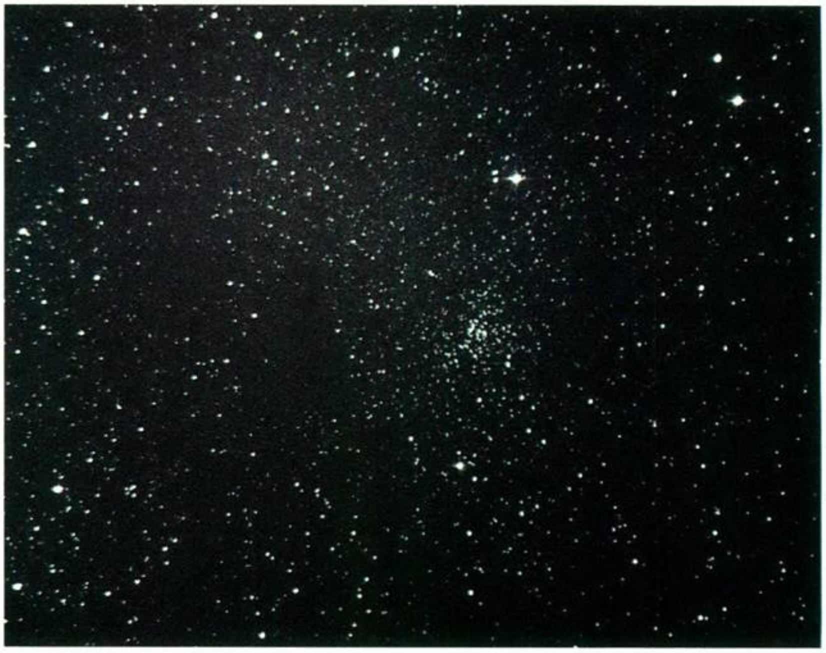
At 2,050 light-years, NGC 225 is one of the closest of Cassiopeia's clusters. Use a low-power eyepiece or binoculars to view this loose cluster. 3,500 light-years distant lies NGC 189 (III2p), another difficult cluster to pick out from the field of stars around it as it contains only 15 stars. The 20 stars of 9th-magnitude Stock 24 (IV2p) are about 1° southeast of Kappa Cassiopeiae, while northwest of the reddish, 5th-magnitude Chi (χ) Cassiopeiae is the open cluster NGC 133.

At the mid-point of the "W" is the erratic variable Gamma (γ) Cassiopeiae. This is a 2.5-magnitude blue-white subgiant. In 1866, the Italian astronomer Father Pietro Angelo Secchi was studying the spectrum of Gamma Cassiopeiae and observed the bright emission lines of hydrogen for the first time. Gamma is ejecting a spherical shell of this gas. In 1937, Gamma Cassiopeiae glowed at magnitude 1.6, but has dimmed erratically since then. North and east of Gamma Cassiopeiae are the emission and reflection nebulae **IC 59** and **IC 63.** If you look carefully in a large scope, you may be able to see dark triangular shapes in these two nebulae, caused by the stellar wind from Gamma. In small scopes and binoculars, these nebulae get lost in Gamma's glow, so try to place Gamma out of your field of view in order to decrease its light.

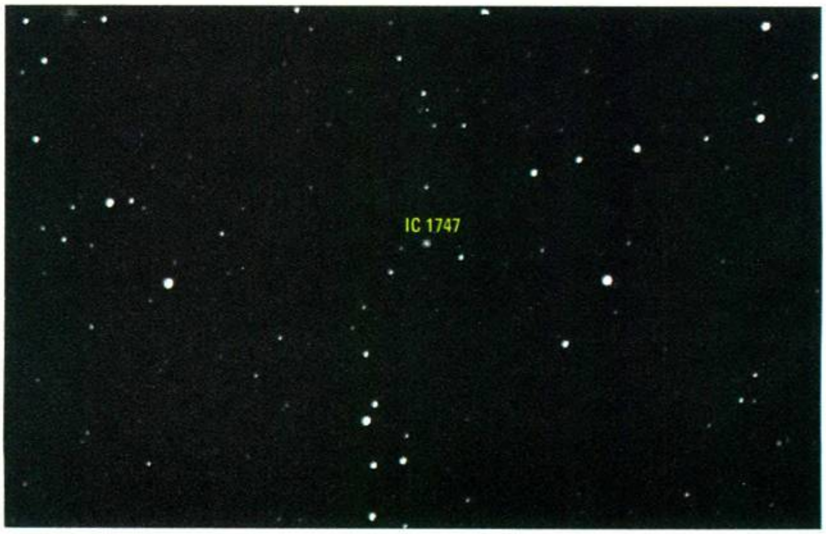
Double Star Delight

With your finder centered on Gamma, you'll see a field dominated by double stars. Also in the view will be two faint clusters, **NGC 381** and **NGC 358.** The 50 stars of NGC 381 (III2p) appear as a hazy lollipop on a stick. NGC 358 (III2m) is harder to locate because it is a tightly compressed group that glows faintly at 10th-magnitude.

As the queen sits on her throne, her knees bend at Delta (δ) Cassiopeia. Delta's Arabic name is Ruchbah, which comes from Al Ruchbah, "the knee." Delta is a blue-white, 2.7-magnitude main-


Lee C. Coombs

NGC 559 (above) is probably the easiest to locate of a starry triangle comprised of it and NGC 637 and NGC 609. With Epsilon (ε) Cassiopeiae on the eastern edge of your field of view, the stellar three should be on the west. IC 1747 (below), a faint planetary nebula, lies southeast of Epsilon.



Martin Germano

Deep-Sky Objects in Cassiopeia

Object	R.A.(2000)	Dec.	Mag.	Size	Type
NGC 103	0h25.3m	61°21'	9.8	5'	oc
NGC 129	0h29.9m	60°14'	6.5	21'	oc
NGC 133	0h31.2m	63°22'	9.4_{P}	7'	oc
NGC 136	0h31.5m	61°32'	11.3	1.2'	oc
King 14	0h31.9m	63°10'	8.5	7'	oc
NGC 146	0h33.1m	63°18'	9.1	7'	oc
NGC 189	0h39.6m	61°04'	8.8	3.7'	oc
Stock 24	0h39.7m	61°57'	8.8	4'	oc
NGC 225	0h43.4m	61°47'	7.0	12'	oc
IC 59	0h56.7m	61°04'	—	10' by 5'	ern
IC 63	0h59.5m	60°49'	—	10' by 3'	ern
NGC 358	1h05.0m	62°02'	—	<10'	asterism
NGC 381	1h08.3m	61°35'	9.3_{P}	6'	oc
NGC 559	1h29.5m	59°09'	9.5	4.4'	oc
M103 (NGC 581)	1h33.2m	60°42'	7.4	6'	oc
Trumpler 1	1h35.7m	61°17'	8.1	4.5'	oc
NGC 609	1h37.0m	64°33'	11.0	3'	oc
NGC 637	1h42.9m	64°00'	8.2	3.5'	oc
NGC 654	1h44.1m	61°53'	6.5	5'	oc
NGC 659	1h44.2m	60°42'	7.9	5'	oc
NGC 663	1h46.0m	61°15'	5.7	36'	oc
IC 1747	1h57.6m	63°20'	13.6	13"	pn
M52 (NGC 7654)	23h24.2m	61°35'	6.9	13'	oc
Harvard 21	23h54.1m	61°46'	9.0_{P}	4'	oc
NGC 7788	23h56.7m	61°24'	9.4_{P}	9'	oc
NGC 7789	23h57.0m	56°44'	6.7	16'	oc
NGC 7790	23h58.4m	61°13'	13.0	17'	oc

This table provides right ascension and declination in epoch 2000.00 coordinates. V magnitude (except a subscript P, which denotes a photographic magnitude). Sizes are given in arcminutes or arcseconds. Type: oc, open cluster; ern, emission and reflection nebula; and pn, planetary nebula.

sequence star located 50 light-years away. It is an eclipsing binary that undergoes a slight drop in brightness when its companion star passes in front of it.

Slightly east of a line between Delta and Epsilon Cassiopeiae is a U-shaped grouping of five clusters. The group consists of **M103** (NGC 581), **Trumpler 1, NGC 654, NGC 663,** and **NGC 659.** These five clusters are 8,500, 7,200, 8,150, 7,200, and 6,850-light years away, respectively. All five of them should fit within a finder scope field of view.

Closest to Delta are the 25 stars of the loose cluster M103 (III2p). The double star Σ131 lies on the southwestern edge of the cluster. Trumpler 1 (I3p) appears as two almost parallel lines of 10th and 11th magnitude stars embedded in a hazy patch of about 20 stars. At the bottom of the "U" is the 6.5-magnitude cluster NGC 654 (II3m). This group is easy to locate in binoculars because it appears as a tiny, bright spot of light surrounded by a loose field of scattered stars.

Forming a rough circle of about 80 stars is NGC 663 (III2m). Glowing at magnitude 5.7, this cluster has 10th, 11th, and 12th magnitude stars in its outer reaches. These outer stars surround and appear to be herding the other 50 or so fainter stars into a tight ball of haze. To me, NGC 659 (III1p) looks somewhat like the letter X with one short leg. On the southwestern fringe of NGC 659 is the 6th magnitude double star 44 Cassiopeiae.

Faint Nebula Challenge Awaits

Back on the trail of Cassiopeia's principal stars, we hop over to Epsilon (ε) Cassiopeiae. Depending on the way the mythological picture of the Queen is drawn, Epsilon marks either her legs or a leg of the throne. This magnitude 3.4 blue-white star lies about 560 light-years away. Southeast of and partly obscured by the glow of Epsilon is the faint planetary nebula **IC 1747.** It is 13" in size with a magnitude of 13.6. Dark skies and a 13-inch telescope should reel-in this somewhat challenging nebula.

Another starry triangle is formed by the three clusters **NGC 637, NGC 609,** and **NGC 559.** These clusters will be in the western side of your finder when you place Epsilon on the eastern edge of your field. NGC 637 (I3p) is smaller and fainter, glowing at magnitude 8.2. NGC 609 (II3r) shines 15 times fainter than NGC 637 at magnitude 11.0, and appears like a dim red bulb alone in the wilderness. Of these clusters, NGC 559 (II2m) is probably the easiest to locate. I see it as a misshapen, five-pointed star with a hole in its center.

You've now added almost 30 celestial jewels to your observing inventory, and given the richness of the Queen's treasure-trove and mild autumnal weather, you'll find yourself coming back here time and again. ☐

Robert A. Garfinkle is the author of Star-Hopping: Your Visa to Viewing the Universe. *His most recent article "See You at the Hop," appeared in* ASTRONOMY*'s August 1995 issue.*

A Winter Rich in METEORS

Wrap up in some warm clothes, relax under a starry sky, and get ready for some spectacular meteors.

by Phil Bagnall

Despite its drawbacks, winter can often be the best time to observe. True, it can be cold — bitterly cold sometimes — but the promise of comet dust blazing its way through the upper atmosphere is enough to warm the hearts of even the most frozen observers. Over the next few months, no fewer than three major meteor showers will be on view, each with its own unique charm.

Out of the many dozen meteor showers that return year after year, the Leonid shower probably ranks as the most important because the birth of meteor astronomy dates to observations of this shower on the morning of November 13, 1833. During the four hours preceding dawn, the night sky above eastern North America lit up time and time again as thousands of brilliant meteors shot across the heavens. To the God-fearing people of New England, it must have seemed as though Judgment Day had arrived. But to astronomers, it was a revelation.

Meteors — the wish-granting shooting stars of popular mythology — were nothing new. They had been observed and recorded by Chinese, Japanese, and Korean astronomers for centuries. Scientists knew that at certain times of the year meteors would appear in certain parts of the sky. But that was about the extent of their knowledge. With a sky full of meteors, however, something else became obvious: Meteors appear to radiate from a single point in the sky (now called the "radiant"). The Leonids take their name from the location of the radiant, in the constellation Leo the Lion.

Back in 1833, no one knew that meteors formed when comet dust burned up in the atmosphere. Sure, there were plenty of theories to explain meteors: hot vapors rising from Earth, hot vapors from the Sun, even hot vapors from other planets. But those theories were all just, well, hot air.

The great storm of 1833 encouraged scientists to take a closer look. Research showed that a previous meteor storm had occurred in 1799 and was witnessed by the German naturalist and explorer Baron Alexander von Humboldt during a visit to Cumaná in South America. American astronomer Denison Olmsted theorized that Earth had encountered a cloud of particles, while German astronomer Heinrich Olbers (best known for Olbers' Paradox) deduced that such an encounter would occur every 33 or 34 years. Sure enough, another Leonid storm took place in 1866, and meteor rates stayed high for several years thereafter.

In December 1865, Ernst Wilhelm Tempel, observing from Marseille, France, discovered a

Charles F. Capen

November 17, 1966, saw a great storm of Leonid meteors, with up to 40 raining down each second. Could the Leonids storm again in the next few years?

Jerry Schad

6th-magnitude comet near the star Beta Ursae Majoris. The discovery was confirmed by Horace P. Tuttle, an American Civil War hero and one of the greatest comet hunters who ever lived. Astronomers Theodor von Oppolzer, Carl Peters, and Giovanni Schiaparelli soon realized the significance of this new comet when they noticed that its orbit was similar to that of the Leonids. They suggested that the Leonid meteors were actual fragments of Comet Tempel-Tuttle, and that the 1866 storm resulted from the comet's return to the inner solar system.

Will the Lion Roar Again?

The last great meteor storm from the Leonids came on November 17, 1966, when observers in the western United States witnessed 144,000 meteors per hour, or 40 meteors per second. With the comet currently nearing perihelion (its closest approach to the Sun comes in 1998), what are the chances of another great storm? And what will this year's display be like?

One person who should know is Donald Yeomans of the Jet Propulsion Laboratory who, along with fellow researchers Kevin Yau and Paul Weissman, has studied the meteor stream in detail. "Enhanced shower activity is likely both this year and next," Yeomans points out, "but if a storm is going to occur then it is most likely to be in 1998 or 1999 — possibly in both years."

That's a big if, however. This time around, Earth passes nearly three times as far from the comet's orbital path as it did in 1966 and more than six times farther than in 1833. The 1998-99 return of the comet more closely resembles those in 1866-68, when observers reported seeing up to 5,000 meteors per hour, and 1931-32, when the maximum rate reached 200 meteors per hour.

This November may give us a glimpse of what is to come in the next few years. Fortunately, observing conditions are very favorable. The shower runs from about November 15 to 20, with maximum activity coming on the morning of November 17. The prime observing hours before dawn will be Moon-free because the nearly first quarter Moon sets shortly before midnight. The shower's radiant lies at right ascension 10h08m and declination 22°, close to the star Gamma Leonis, where the neck of the Lion meets its body.

December's Geminid shower produces many bright meteors, like this one slicing through Monoceros and disappearing beyond the horizon.

Leonid meteors enter Earth's atmosphere at almost 72 kilometers per second (162,000 mph) — the fastest of any shower meteors — and burn up at altitudes between 128 and 88 km. The meteors are often bright and, during storms, can produce a large number of fireballs. A high percentage also leave persistent smoke trails in their wake.

Yeomans calculates that the peak this year will occur at about 7h20m UT on the 17th (2:20 a.m. EST) but adds that this time could be off by several hours. If he is right, the shower will favor those in the eastern United States, who

Rick Schmidt

An observatory dome makes a fitting foreground for this bright Geminid (above), but even the trailed branches of a leafless tree work well (below).

Michael Searle

will be heading into the stream just as their friends in Europe are packing up for the night. With the best chance of enhanced activity being on Saturday night into Sunday morning, why not make an effort to observe the Leonids this year? You could be in for a pleasant surprise.

Meteors from the Twins

A couple of weeks after the Leonids have died down, another great shower begins to pick up: the Geminids. Although they are more prolific than the ever-popular Perseids in August, the Geminids occur in the dead of winter and are often observed only by hardened meteor watchers. It's a pity, really, because they often put on a much better show.

Earth starts to encounter the Geminid stream on about December 7 and catches the last stragglers on December 16. Activity builds slowly for about a week, peaks around December 13, then falls off rapidly. But the shower hasn't always behaved this way. Observations from early this century showed a sudden rise to maximum followed by a gradual decline. Some astronomers have suggested that this shift could result from a tight core of meteoroids moving sideways relative to Earth (see "Observe the Geminids Before They Disappear," December 1990). If true, the stream will drift past Earth by early next century and the shower will essentially disappear.

Unlike most meteor showers, the Geminids do not appear to have a parent comet. Instead, they seem to have a parent asteroid, called 3200 Phaethon.

At first this discovery puzzled astronomers, but most now argue that Phaethon was once a comet that boiled off all of its volatiles during its numerous returns to perihelion, leaving behind an inert nucleus. Of course, they could be wrong. Phaethon might be a true asteroid (a rocky fragment left over from the planet-building process) that just happens to be in the same orbit as the Geminids.

As with the Leonids, observing conditions for the Geminids this year are excellent. From North America, the shower peaks on the morning of December 13, when the Moon is three days old and won't wash out the fainter meteors. The Geminids radiate from right ascension 7h28m and declination 32°, near the 1st-magnitude star Castor (Alpha Geminorum).

Terence Dickinson

A Geminid meteor cuts across Taurus in 1990, below Mars and the Pleiades.

Gert Kroner

A pair of Quadrantids streak past Jupiter on January 4, 1992. Although often overlooked, the Quadrantid shower ranks among the most prolific.

Observers living in the southern United States have a better view of the shower because the radiant lies high in the sky for most of the night. People there can expect to see up to 90 meteors per hour from a dark site. The radiant appears lower in the sky the farther north you live, but even so, the shower could easily produce 65 to 75 meteors per hour.

The Geminids do not travel as swiftly as the Leonids, entering the atmosphere at 36 km/s. Their

Gert Kroner

The frigid nights of early January offer meteors radiating from the ancient constellation of Quadrans Muralis.

slower speed means they penetrate farther into the atmosphere, to an altitude between 100 and 80 km, before burning up. The Geminid shower tends to be rich in both fireballs and faint meteors, so it pays to keep your eyes peeled.

Obscure but Rewarding

Just three weeks after the Geminids, winter's final good meteor shower takes the stage. The Quadrantids, named after the now defunct constellation Quadrans Muralis, runs from about January 1 to 6 with maximum occurring on the night of January 3/4.

The highlight of this shower is the large number of yellow and blue fireballs it typically produces. Although a waning crescent Moon interferes a little this year, the fireballs easily stand up to the extra light and make it well worth the effort to observe the Quadrantids.

The shower radiates from a point at right ascension 15h28m and declination 50°, close to where Bootes, Draco, and Hercules all meet. For most of the week the shower has a fairly large, diffuse radiant, but at maximum the radiant shrinks markedly, indicating a dense central core of meteoroids. The meteors strike Earth's atmosphere at moderate speeds of 43 km/s and burn up at altitudes between 103 and 91 km. Even so, their brightness can deceive you into believing they are just a few miles above your head.

After the Quadrantids fade away, most meteor watchers take a well-deserved break. Although a few minor showers make their appearances as winter drags on, activity doesn't really pick up until the Lyrids arrive in mid- to late April. The layoff gives observers plenty of time to recharge their batteries in anticipation of the next season of meteor viewing. ☐

Phil Bagnall is an amateur astronomer living in the north of England. He regularly profiles meteor showers for ASTRONOMY.

How to Observe Meteors

Rick Schmidt

If you can handle the often cold temperatures, observing winter's meteors couldn't be easier. You don't need any special equipment, and you can observe from any location well away from the city and the glare of streetlights. Here are a few tips to make the experience more enjoyable:

- Dress warmly (or wrap yourself in a sleeping bag) and be sure to bring a thermos of hot coffee, tea, or soup, along with some snacks to eat.
- Don't look directly at the radiant, where any meteors would leave very short streaks. Observe roughly 45° from the radiant and about the same distance above the horizon.
- Watch the skies for about 50 minutes, then take a 10-minute break. If it is bitterly cold, break every 30 minutes. Don't skimp on breaks: They help you observe longer and ward off the effects of the cold.
- When you see a meteor, trace its path back across the sky and see if it intersects the radiant. If it does, it belongs to the shower, otherwise it is a "sporadic." If you want to get technical, also note the meteor's magnitude, color, and time of appearance.
- If you observe for a week or so around the peak of the shower, try plotting a graph of the number of meteors you observe against time to see how the activity rises and falls.

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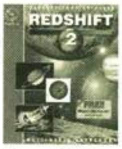

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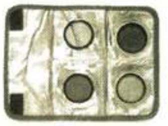

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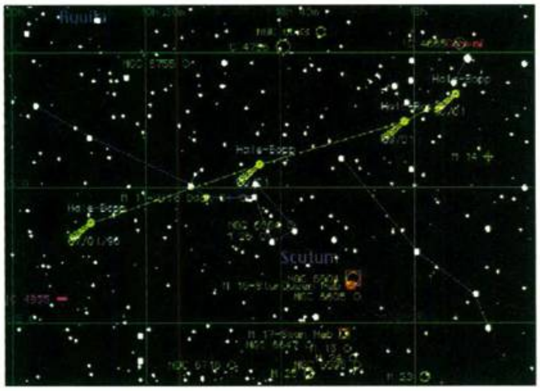
ASTRO BYTES

Observer 2.0 Level 2



Amateur astronomers with laptops are almost commonplace at observing sessions, and now *Observer 2.0* Level 2 extends this capability for Macintosh computer owners. Although equally useful at home on a desktop Mac, *Observer* is designed for use with a telescope, and its strengths lie in being an observing tool. With its ephemerides, charts, databases, and logs, *Observer* helps fill a niche in Mac-based astronomy software. *Observer* interfaces directly to the Meade Magellan and LX200 telescopes; otherwise, telescope automation is managed with the ScopeLink interface. Procyon Systems also customizes interfaces.

Observer is available with three database "level" options, from 23,000 to 300,000 objects, starting at $49.95. A free demo of *Observer 2.0* Level 2 is available at Procyon's world wide web site.

Procyon Systems, 1322 Augusta National Boulevard, Winter Springs, FL 32708, (407) 366-5985, e-mail observer@procyon-sys.com, http://www.procyon-sys.com. Price: $99.95 (Level 2 — 300,000 objects). Minimum requirements: Apple Macintosh or PowerBook, Color QuickDraw, System 7.0, 2.5 MB free memory, and 13.5 MB free hard drive space. Computers with 68K processors require a math coprocessor.

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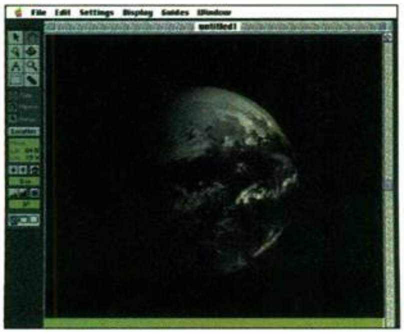
Procyon Systems, 1322 Augusta National Boulevard, Winter Springs, FL 32708, (407) 366-5985, e-mail observer@ procyon-sys.com, http://www.procyon-sys.com. Price: $225 (includes Scopelink Interface, 15 foot encoder cables, Mac serial cable, and two 4,000 step optical encoders); $299.95 (Observer 2.0 Deluxe — Observer and Scopelink).

Starry Night



Starry Night is an easy-to-use planetarium program for the Macintosh. No location is too remote to view the sky with *Starry Night* — even the Moon. Additionally, parents may learn the constellations with their children and watch solar eclipses. Educators, students, amateur astronomers, and anyone interested in the night sky may find this software valuable.

Sienna Software, Inc., 105 Pears Avenue, Toronto, Ontario, M5R 1S9, Canada, orders (800) 252-5417, technical support (416) 926-2174, e-mail contact@siennasoft.com, http://www.siennasoft.com/sienna. Price: (Downloaded registered version) $28, (Registered diskettes) $37. Minimum requirements: Macintosh System 7 color-capable computer, 4 MB RAM.

MegaStar 3.0

MegaStar Sky Atlas for Windows, Version 3.0, is suitable for amateur astronomers at all levels and allows the user to make detailed finder charts for deep-sky objects, asteroids, and comets.

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MegaStar's various features include options for customizing the charts and display, deep-sky objects plotted to scale, eyepiece view, CCD framer, and more. *MegaStar* also interfaces directly to the Meade LX200 and Sky Commander digital setting circles.

E.L.B. Software, 8910 Willow Meadow Drive, Houston, TX 77031-1828, (713) 541-9723, e-mail: elb@ix.netcom.com. Price: $129. Minimum requirements: 80386 computer with math coprocessor, 4 MB RAM, 5 MB free hard drive space, Windows 3.1 (Win95 compatible), CD-ROM drive.

Product information is as provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY's home page at **http://www.kalmbach.com/astro/astronomy.html**

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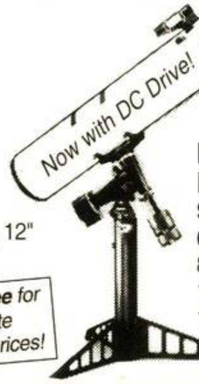

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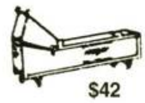

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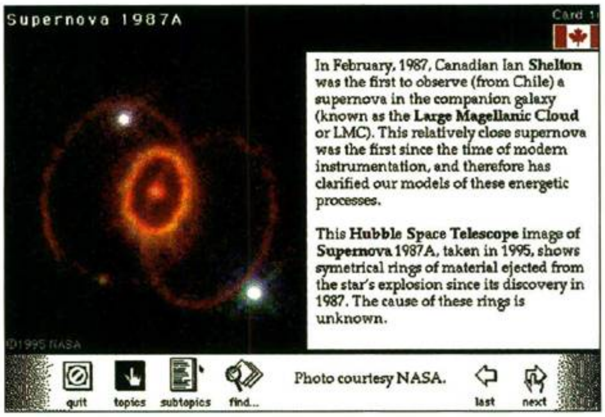
Five hundred screens covering topics from observing the night sky to the evolution of the solar system and beyond are contained in Mount Allison University's educational CD-ROM, *Fundamental Astronomy* — from observation to understanding. Geared to introductory astronomy students and educators at high school and university levels, this CD-ROM for the Macintosh will pique the interest of amateur astronomers of all ages.

Fundamental Astronomy was funded by a grant from TeleEducation New Brunswick, with the aim of providing the university experience to students unable to attend Mount Allison. Highlights include original interview clips with David Levy, Alan Hildebrand, and others, computer generated QuickTime animations, and interactive constellation lines and hidden messages that enable users to explore and discover at their own pace. Teachers will appreciate the topic-specific bibliography with references. All the materials are available in a printable version for use as lecture or study notes for those without access to computer hardware.



In February, 1987, Canadian Ian **Shelton** was the first to observe (from Chile) a supernova in the companion galaxy (known as the **Large Magellanic Cloud** or LMC). This relatively close supernova was the first since the time of modern instrumentation, and therefore has clarified our models of these energetic processes.

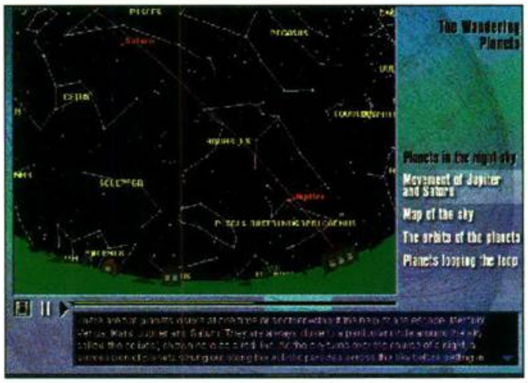
This **Hubble Space Telescope** image of **Supernova** 1987A, taken in 1995, shows symetrical rings of material ejected from the star's explosion since its discovery in 1987. The cause of these rings is unknown.

Photo courtesy NASA.

Mount Allison University Bookstore, P.O. Box 1230, Sackville NB E0A 3C0 Canada, (506) 364-2225, e-mail astrocdinfo@mta.ca, http://aci.mta.ca/Fundamental/. Price: $49.95 (Canadian). Minimum requirements: Macintosh System 7 computer, 9-inch color or grayscale monitor (256 color or gray range), double-speed CD-ROM, 4 MB RAM.

Discover Astronomy™

Jacqueline Mitton, author of the Penguin Dictionary of Astronomy, wrote the script for this richly illustrated CD-ROM in which the user is guided through lessons in full-motion 3D virtual reality simulations. The creators of *Discover Astronomy*™ invite you to sit back and watch the secrets of the universe unfold on your desktop with nine narrated, animated 2D and 3D tours that describe the evolution of the universe from the Big Bang to the development of life on Earth. The Solar System appears, along with stars and galaxies beyond. *Discover Astronomy*™ includes a photo gallery, music from "Redshift Suite," and more.



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StarShow Viewer

StarShow Viewer is a shareware astronomy program that displays stars, constellations, planets, galaxies, nebulae, and star clusters. The location, angle, or time of your view of the sky can be changed to any perspective, and animation features can change the view automatically at selectable time intervals. *StarShow* can also be used as a screen saver.

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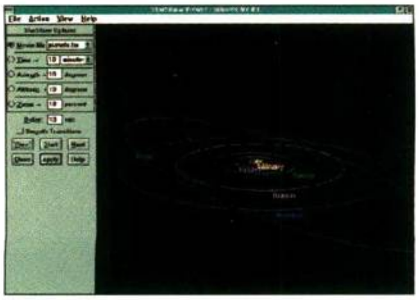

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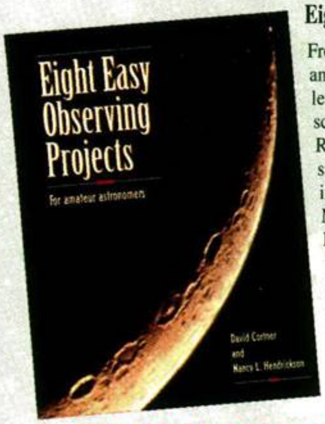

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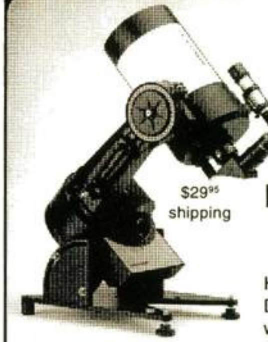

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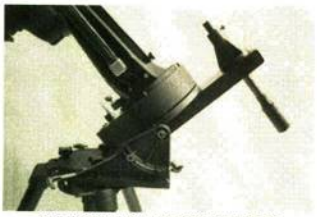

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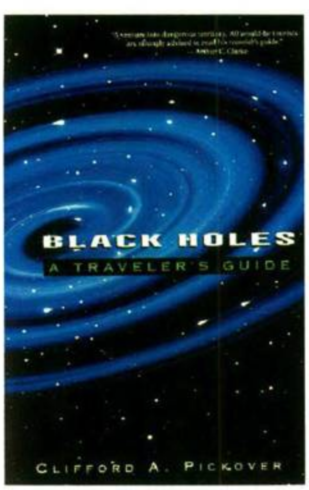
Black Holes: A Traveler's Guide

Clifford A. Pickover, (John Wiley & Sons, 1996), ISBN 0-471-12580-6, 210 pages, hardcover, $24.95.

What would it be like to visit a black hole? What information could be gathered on a visit to one of these fascinating places? Black holes have intrigued scientists and science fiction writers for several decades. Many books, both descriptive and theoretical, have been written on the subject. The former tend to be a bit more fanciful than called for by the known facts, and the latter can be understood only by astrophysicists. Now we have a book that splits the difference.



In this book, the reader is the captain of a spaceship that has encountered a black hole. With the assistance of the first officer, the reader conducts a number of experiments that reveal the nature and properties of a black hole, such as its mass, event horizon circumference, and tidal forces.

Pickover, a science writer and IBM researcher, begins each chapter with a "dialogue" between the captain and first officer concerning the experiment to be performed. This discussion introduces the equation that describes the property under discussion and a range of solutions for black holes of various sizes. The computer programs for these equations, in both BASIC and C, are included in an appendix so that readers may experiment on their own. Most of the equations can also be solved on hand calculators following the steps given in the dialogue. The mathematically challenged will not miss anything by going directly to the solutions given. Most of the chapters also have a section titled "The Science Behind the Science Fiction" that further discusses the concept.

The term "black hole," which first appeared in print in 1968, is somewhat of a misnomer. If you were able to look below the event horizon, you would not see completely empty space. The singularity at the center is constructed of a seething froth known as quantum foam. The probability of the foam being in a particular shape is governed by quantum gravity. Embedded in this foam are the tunnels and wormholes that might lead to different universes or different parts of the same universe. Using the most recent scientific papers, Pickover takes the reader on a journey through one of these wormholes, with results worthy of "The Twilight Zone."

Black Holes: A Traveler's Guide is constructed logically, with each chapter depending on the previous one. In this way the reader is slowly led to a deeper understanding of what black holes are and how scientists think they may be constructed. The only exception is the Black Hole Game, introduced in Chapter 13. This game can be played by anyone — black hole knowledge is not necessary — and might be a good way to introduce children to the concept.

Pickover has aimed the book at science fiction writers, computer hobbyists, and beginning physics and astronomy students. Because his style is very readable and he does provide a thorough explanation of the equations, any reader with some knowledge of black holes will also benefit from it. □

Stephen H. Peters (speters@nmu.edu) is a professor of library science at Northern Michigan University.

Other Books

The Nature of Space and Time

Stephen Hawking and Roger Penrose, (Princeton University Press, 1996), ISBN 0-691-03791-4, 141 pages, hardcover, $24.95.

Two of the greatest minds in contemporary science debate whether or not the two pillars of 20th century physics, quantum mechanics and general relativity, can be combined into a single theory of everything. Hawking says yes, Penrose says no. Each author has three chapters to make his point, with each chapter being based on a recent lecture. The final chapter takes the form of a debate. While the book is utterly fascinating and touches on some of the deepest issues in science, it is not for the casual reader — it contains a bevy of calculus equations and complex geometric diagrams.

Other Suns. Other Worlds? The Search for Extrasolar Planetary Systems

Dennis L. Mammana and Donald W. McCarthy, Jr., (St. Martin's Press, 1996), ISBN 0-312-14021-5, 225 pages, hardcover, $24.95.

Starting with the ancient Greeks, this book chronicles humanity's quest to find planets beyond the solar system. The authors, who are both astronomers, examine the many different search methods along with the false alarms that have plagued the effort to detect extrasolar planets, particularly the controversial claim that Barnard's star has planets and the mystery surrounding the disappearance of VB8's brown dwarf companion. The book also contains a discussion of extraterrestrial life.

Unfortunately, the book was written before the discovery of the first planets orbiting other Sunlike stars. The 51 Pegasi planet is briefly mentioned in the epilogue, and the 70 Virginis and 47 Ursae Majoris planets only make their way into a diagram caption. While the book was dated as soon as it hit bookstore shelves, it provides an excellent historical overview of the search right up to the time astronomers hit paydirt.

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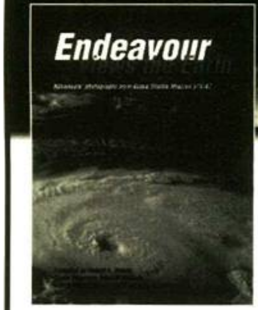

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Kitty Ferguson

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Volcanoes of the Solar System

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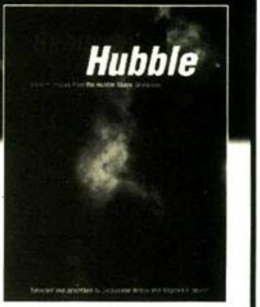

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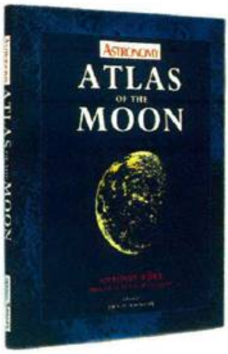
Antonin Rükl, (Kalmbach Books, 1996), ISBN 0-913135-17-8, 223 pages, hardbound, $34.95.

The second printing of this lunar atlas starts with a 26-page introductory section that discusses lunar motion, geological history, and cartography. This is followed by a brief chapter on how to become acquainted with the Moon at various phases. The bulk of the book is devoted to a 152-page, 76-plate atlas of the Moon's near side showing detail down to one kilometer. Each plate gets a two-page spread; the left page presents data on features found on the facing plate. The remainder of the book includes detailed maps of libration zones, profiles of 50 interesting areas, tips on observing and photography, a table of eclipses through 2011, and a glossary and bibliography. *Atlas of the Moon* is an ideal addition to any lunar observer's bookshelf, be they beginner or advanced. From the publishers of ASTRONOMY.



The Ever-Changing Sky: A Guide to the Celestial Sphere

James B. Kaler, (Cambridge University Press, 1996), ISBN 0-521-38053-7, 495 pages, hardcover, $39.95.

This book by University of Illinois astronomer James Kaler was conceived as a cross-disciplinary guide to astronomy. It develops into a comprehensive treatment of all aspects of the sky that could be useful to astronomers, whether they are professionals, amateurs, or students, and to general readers who simply wish to learn about the night sky. Although mathematics is a constant presence in this book, the volume has few equations and the geometry is couched in nontechnical terms that are thoroughly explained. The book is filled with diagrams, sky charts, and black-and-white photographs. Kaler's warm writing style makes this book a thoroughly enjoyable read.

The Origin and Evolution of the Universe

Ben Zuckerman and Matthew A. Malkan, editors, (Jones and Bartlett, 1996), ISBN 0-7637-0030-4, 152 pages, paperback, $28.75.

Based on a symposium held at UCLA in March 1995, this book contains seven chapters, each written by a prominent astronomer or physicist. The book's title pretty much tells what it is about: It's a comprehensive guide to the universe starting with the Big Bang. It later moves to the origin and evolution of galaxies, then to the birth of stars and planets, then to neutron stars and black holes. The final chapters cover the origin of elements, the possibility of life in the universe, and the future of the universe. The book is chock full of information presented at a slightly higher technical level than articles in ASTRONOMY. Editors Zuckerman and Malkan are both astronomers at UCLA. You can order the book directly from the publisher by calling 1-800-832-0034.

The Monthly Sky Guide, Fourth Edition

Ian Ridpath and Wil Tirion, (Cambridge University Press, 1996), ISBN 0-521-56839-0, 64 pages, paperback, $14.95.

The fourth edition of Ian Ridpath and Wil Tirion's guide to the night sky is updated for planet positions to the end of the year 2000. It includes applicable meteor showers and constellation information for each month. A new, additional feature is a monthly listing of solar and lunar eclipses. The introduction is filled with comprehensive, yet easy to understand explanations for common astronomical terms. This book should be of interest to astronomical observers of all levels. ☐

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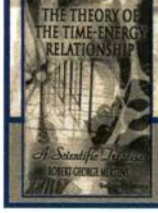

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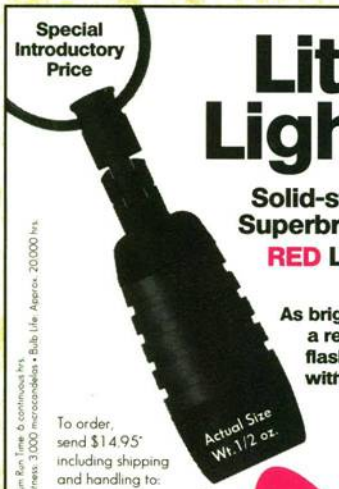

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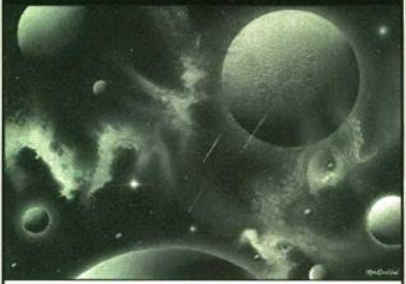

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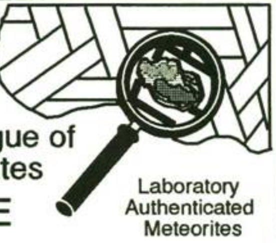

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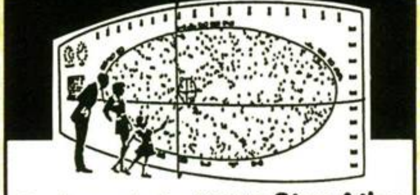

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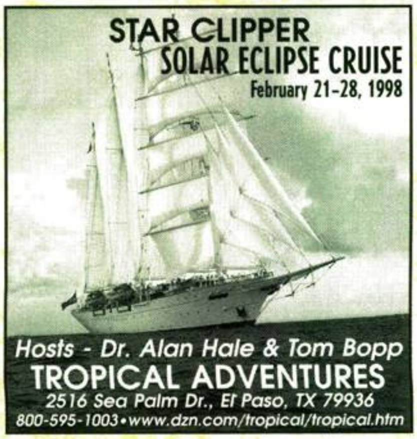

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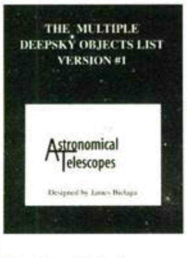

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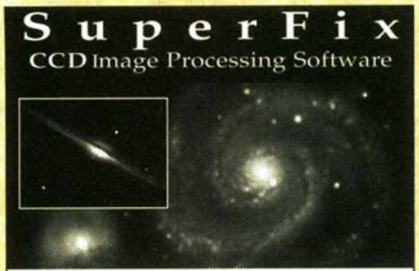

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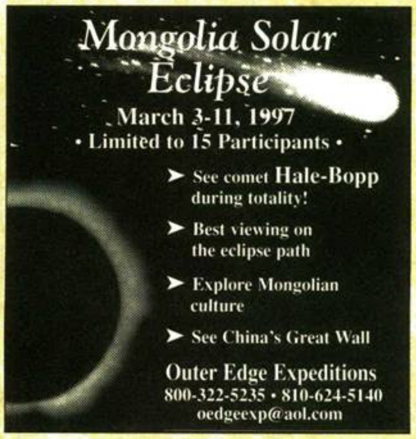

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Accessories For Sale

Build low cost kits. Binocular viewer and single/dual axis computer controlled equatorial platform for your Dobsonian. TL Systems, 2184 Primrose Avenue, Vista, CA 92083. http:www.sunspots.com/tlsystems/ or tlsystem@ix.netcom.com (619) 599–4219.

Star spectroscopes: visual/ photographic/ CCD. Used in universities. $189. Free information: Rainbow Optics, 1593 "E" Street, Hayward, CA 94541, (510) 581–8266.

Binoculars For Sale

Comet binoculars; Russian 12x40 $70.00, 12x45 $80.00, 15x50 $95.00. Limited supply. Pete Rasmussen (501) 362–5670.

Books and Periodicals For Sale

1973 - 1995 ASTRONOMY magazines. Some copies missing. (206) 854–2410.

ASTRONOMY 8/73- 5/87, except 10/73. James Duncan, 1203 NW 11th, Bentonville, AR 72712, (501) 273–7333.

PROPHESY AND THE COMET. Amazing book! Researches comet omens from the Exodus comet Typhon (1450 B.C.) to Shoemaker-Levy 9's recent Jupiter bombardments. Reveals S-L9's incredible connection with the apocalypse. Only $8.95 payable to Celtica, Box 2584, Orange Park, FL 32067-2584.

SKY & TELESCOPE, March 1972 through April 1982, March 1975 missing. $240.00. (517) 348–9610.

Organization Announcements

The Des Moines Astronomical Society would like to alert the amateur astronomy community of a theft. On Sunday, July 21st, our observatory was broken into and several astronomy related items stolen. Included in the loss, a SBIG ST-4 CCD (SN#419306817), an 8" Parks Newtonian/Cassigrain, a Celestron C5 with tripod, several eyepieces and much more. If you have any information please contact Bryan Butcher at (515) 255–1585 or the Jasper County Sheriff at (515) 792–5912.

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Wanted: Old Edmund Scientific telescopes, any type, any condition or parts. Paul Rini, Box 224 Main Street, Maple Shade, NJ 08052-0224, (609) 667–0783 mornings.

Wanted: no- longer- used telescopes, parts and accessories. Contact Gary Hand, 24045 Sugarcane Ln., Gaithersburg, MD 20882. (301) 253–5046 evenings.

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Astronomical Checks

This series of specialty checks from Styles Checks shows three different astronomical scenes. One has an artist's rendering of the Horsehead Nebula with a Newtonian telescope in the foreground. Another portrays the Hubble Space Telescope soon after deployment in Earth orbit. The final scene depicts Saturn and its family of moons, based on Voyager imagery. Checkbook cover and deposit slips come at no charge. Specify single form or duplicate, carbon-copy version.

The Styles Check Company, 22600 Lambert St., Suite #1203, Lake Forest, CA 92630; (800) 356-0353 or (714) 597-4944; fax, (714) 597-4949. The Astronomy check design: Single-style checks come in pads of 200 ($13.95), 400 ($25.95), 600 ($35.95), and 800 ($42.95). Carbon-duplicate style, pads of 150 ($15.95), 300 ($28.95), 450 ($39.95), and 600 ($49.95).

New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

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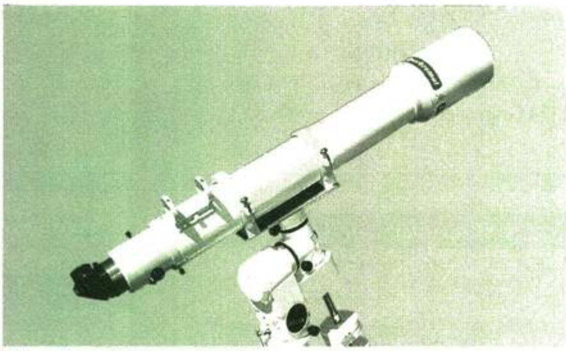

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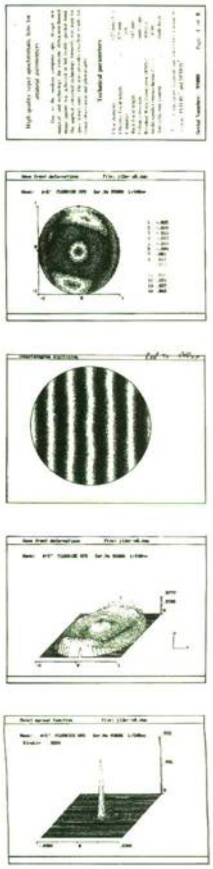

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Celestron International, 2835 Columbia Street, Torrance, CA 90503; (310) 328-9560; fax, (310) 212-5835. Disposable Red-light Keychain Light, model # 93590: $5.90.

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Coastline Community College offers a series of award-winning astronomy programs that were produced for colleges nationwide and broadcast on educational television. Twenty-six individual lessons comprise the video, with each lasting 30 minutes. The series is packaged on 13-videocassettes, and has an optional textbook and student study guide for home study.

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Coast Telecourses, Coastline Community College, 11460 Warner Avenue, Fountain Valley, CA 92708-2597; (714) 241-6109; fax, (714) 241-6286. Universe: The Infinite Frontier Video Telecourse: $39.95 per two-lesson tape.

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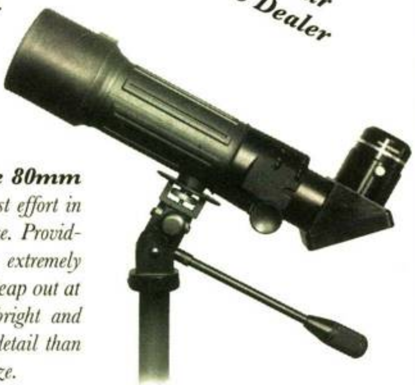

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RESOURCES
PHOTOFACTS

Life on Mars (page 48)

"Search for Past Life on Mars: Possible Relic Biogenic Activity in Martian Meteorite ALH84001," by David S. McKay, et al., *Science*, August 16, 1996. The scientific paper announcing the analysis of the martian meteorite. Technical.

http:/cu-ames.arc.nasa.gov/marslife A website chock-full of images and information.

"Living Planet," by Shawna Vogel, *Earth*, April 1996. Why Earth has bountiful life and why our neighbors Mars and Venus do not.

"Jack Farmer, Exopaleontologist," by Blake Edgar, *Discover*, October 1995. A profile of a leading expert on the search for martian life.

"Did Mars Once Have Martians?" by Christopher P. McKay, ASTRONOMY, September 1993. A renowned planetary astronomer examines how Mars' climate has changed over eons, and why scientists think that Mars could have once supported life.

The Planetary Report, January/February 1996. Three articles discuss upcoming missions to Mars: NASA's Pathfinder and Surveyor spacecraft, and the Russian Mars '96 probe.

Galileo's Dazzling Flyby (page 56)

Satellites of the Outer Planets by David A. Rothery (Clarendon Press, 1992). This book looks at all the large moons in the outer solar system, including Jupiter's, from a geological perspective. Intended for the layman with at least some background either in astronomy or geology.

The Giant Planet Jupiter by John H. Rogers (Cambridge University Press, 1995). A non-technical introduction to the planet and its moons that discusses both amateur and professional observations.

Satellites, edited by Joseph A. Burns and Mildred Shapley Matthews (University of Arizona Press, 1986). A technical discussion of all the major satellites in the solar system, including separate chapters on Io and Europa.

A Winter Rich in Meteors (page 90)

Meteor Showers: A Descriptive Catalog, by Gary W. Kronk (Enslow Publishers, 1988). Provides detailed information on several dozen meteor showers visible each year.

p. 64: Jupiter, Donald Parker, Kodak Ektachrome 200, 20-inch f/6 reflector, 5-second exposure on July 27, 1985; **p. 69, left:** M34, Robert Provin, GAF 200 slide film (no longer produced), 6-inch f/5 reflector, 25 minutes; **right:** M15, Lee C. Coombs, Kodak Ektachrome P1600, 10-inch f/5 reflector, 20 minutes; **p. 70:** Paul Hodge, Kitt Peak National Observatory; **p. 71:** Comet Hale-Bopp, James R. Foster, hypered Fuji HG 400, 11-inch f/6.3 Schmidt-Cassegrain, 60-minute exposure on July 21, 1996; **p. 72: M67,** David Ratledge, 3M 1000 slide film (no longer produced), 12.5-inch f/6 reflector, 14 minutes; **p. 84:** Mark Park, M52, NGC 7635, NGC 7538, NGC 7510, Sk2-157, K 19, 6-inch f/7 Astrophysics, hypered Fuji 400, composite of two 60-second exposures; **p. 85, upper left:** Martin Germano, NGC 129, 8-inch f/10 Schmidt-Cassegrain, 103 AF film, 45 minutes; **upper right:** Lee C. Coombs, NGC 7790 and NGC 7788, 10-inch f/5, 103a-0 film, 10 minutes; **center:** Lee C. Coombs, Harvard 21, 10-inch f/5, 103a-0 film, 10 minutes; **bottom:** Lee C. Coombs, NGC 7789, 10-inch f/5, 103a-0 film, 10 minutes; **p. 86, upper right:** Gary Emerson, NGC 225 and meteor; **lower right:** Lee C. Coombs, NGC 133, NGC 146, 10-inch f/5, 103a-0 film, 10 minutes; **p. 87, upper right:** Lee C. Coombs, NGC 654, NGC 663, and NGC 659, 10-inch f/5, 103a-0 film, 10 minutes; **lower left:** J.C. Mirtle, IC 59 and IC 63, 8-inch f/6, hypered 2415, 60 minutes; **lower right:** Martin Germano, Trumpler 1 and M103, 8-inch f/5, hypered 2415 film, 30 minutes; **p. 88, upper right:** Lee C. Coombs, NGC 559, 10-inch f/5, 103a-0 film, 10 minutes; **lower right:** Martin Germano, IC 1747, 8-inch f/10 Schmidt-Cassegrain, 103 AF film, 7 minutes; **p. 90:** Charles F. Capen on November 17, 1966; **p. 91:** Jerry Schad, 24mm lens at f/1.4, Ektachrome P1600 film at ISO 3200, December 14, 1994; **p. 92, top left:** Rick Schmidt, Geminid meteor; **top right:** Terence Dickinson, 35mm lens at f/2, 2-minute exposure on December 13/14, 1990; **bottom left:** Michael Searle, Geminid meteor; **bottom right:** Gert Kroner, 40mm lens at f/12.8, 10-minute exposure on January 4, 1992; **p. 93, top:** Gert Kroner, 50mm lens at f/12.8, 10-minute exposure on January 4, 1992.

MEETINGS
EVENTS

Cosmic Voyage, IMAX film, Langley Theater, Smithsonian Institution's National Air and Space Museum, Sixth St. and Independence Ave. SW, Washington, DC.

November 1-3
American Assn. of Variable Star Observers Annual Meeting, Cambridge, Massachusetts. Contact AAVSO, 25 Birch Street, Cambridge, MA 02138, (617) 354-0484, Fax: (617) 354-0665, aavso@aavso.org.

November 2
AstroImage 96 Seminar, California State University, Ruby Center, Fullerton, California. Registrar: Charlie Oostdyk, P.O. Box 1762, Costa Mesa, CA 92628, charlie@cccd.edu.

November 6
The World Beyond Us, a program for young adults ages 11 and up, Portage Lakes Library, Akron, Ohio. Contact 330-643-9106, 216-861-4587.

November 6-9
Fifth Annual Star Party, Lake Kissimmee State Park, 15 miles east of Lake Wales, Florida. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853, (941) 696-3472.

November 8-9
East Coast Star Party, Coinjock, North Carolina. SASE to Kent Blackwell, 1169 Old Kempsville Road, Virginia Beach, VA 23464.

November 8-9
Public Star Party, Lemon Lake County Park, Indiana. Sponsored by the Calumet Astronomical Society. Contact Craig Woodley, P.O. Box 851, Griffith, IN 46319, (219) 836-4225.

November 8-10
The Universe through Metaphor Weekend Retreat/Star Party, Mission San Miguel, San Miguel, California. Contact Jim Carlisle, (805) 543-2198, Rosemary Wilvert, (805) 544-8365. □

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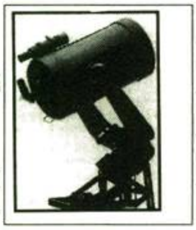

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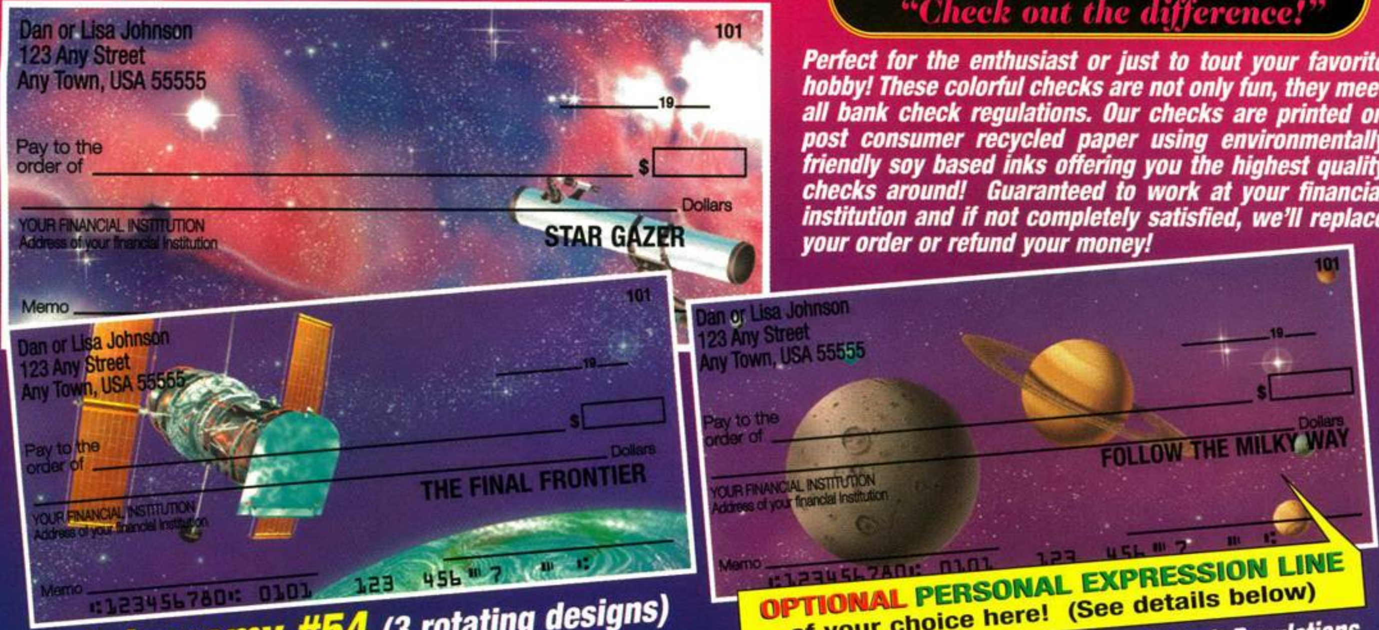

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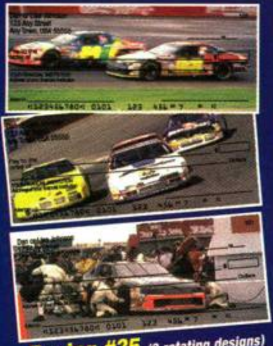

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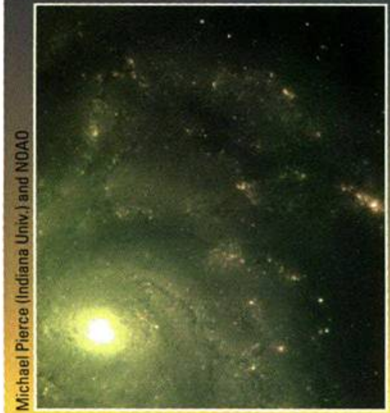
Michael Pierce (Indiana Univ.) and NOAO

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Finding your way around the night sky can be a tricky business, but with the right atlas by your side, you'll be observing like an old pro in no time.

INSIDE THE SAGITTARIUS DWARF
As the Milky Way Galaxy rips apart this small companion, astronomers ponder whether similar encounters in the past helped the Milky Way grow so big.

WISH UPON A STAR
The international space station could play an important role in astronomical research — if we want it to.

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Good Things Come in Threes

A satellite's moving form against the stellar backdrop has become commonplace for even the most casual of skywatchers.

Unless the moving stars form a tight formation of three.

This is what several observers saw in mid-August while gearing up for the Perseid meteor shower. Wisconsin observer Scott Kroeger and his family spied the satellite trio on Friday night, August 9, cruising southeast near Albireo in Cygnus.

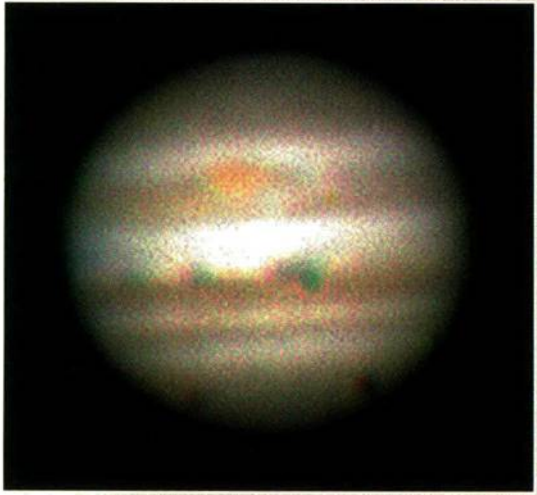
"At first we thought they were planes, but we saw no flashing lights," he relates. "About a minute after we spotted them, they vanished all together, suggesting they moved into Earth's shadow."

Intelligent Satellite Tricks. Canadian Rolf Meier and his meteor observing team in Ontario report another twist. On August 10, he notes, the satellites were moving from south to north, while on the 11th they traveled from north to south. "Does anyone know how new this technology is?" asks Meier.

Ted Molczan of the Canadian Space Society might have an answer. He suggests observers were witnessing an overflight of a secret, steerable naval ocean surveillance system launched recently, code named Whitecloud.

According to Molczan,

Rho Ophiuchi-Scorpius Complex
Bill and Sally Fletcher
(8-inch Schmidt camera, tricolor exposure on hypered Tech Pan film)



Jupiter
Gregory Terrance
(16-inch f/5 reflector, prototype Celestron CCD camera)

Comet Hale-Bopp on July 13, 1996
Gerald Rhemann and Franz Kersche
(8-inch Schmidt camera, Kodak Gold Pro 400 film, 5-minute exposure)

Whitecloud is a cluster of three satellites that fly in a group. He mentions they usually shine at magnitude 5 or 6, but brighten to 0 or 2 depending upon favorable lighting. Molczan posts orbital elements for these and other satellites on an Internet FTP site at kilroy.jpl.nasa.gov/pub/space/elements/molczan.

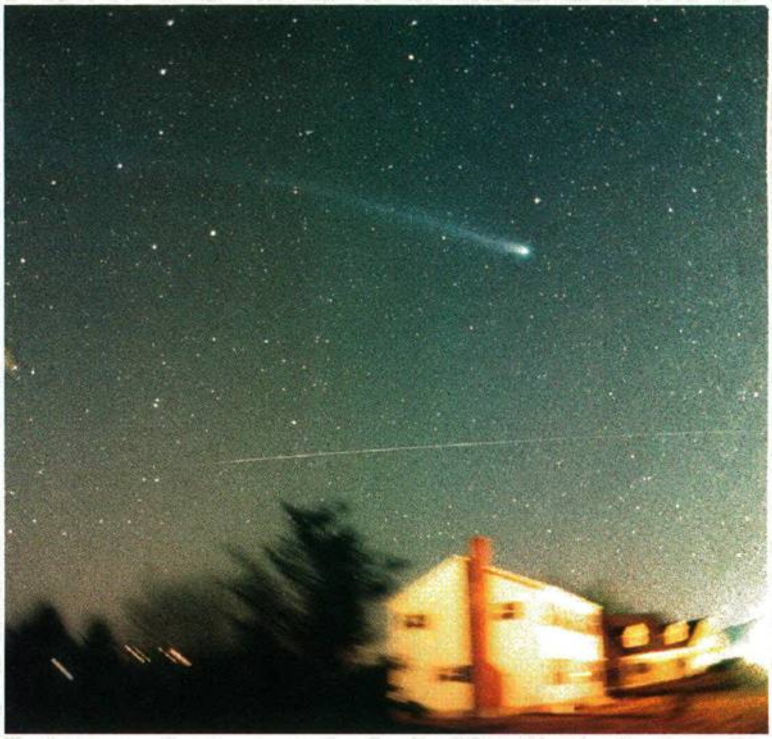
Atlanta, Georgia, satellite enthusiast Harry Taylor used Molczan's data in a satellite position program he runs on a home computer. He finds the formation made an excellent pass over eastern North America on August 10.

Art Intones Life. Requiring a bit more explanation is NASA's announcement of fossilized lifeforms found encased in a martian meteorite. Regardless of the scientific outcome, Pennsylvania amateur astronomer Marty Peritsky felt inspired to write this piece of haiku that reflects a buoyed space agency's hopes. (Recall haiku has a 5-7-5 repetition for syllables in lines one, two, and three)

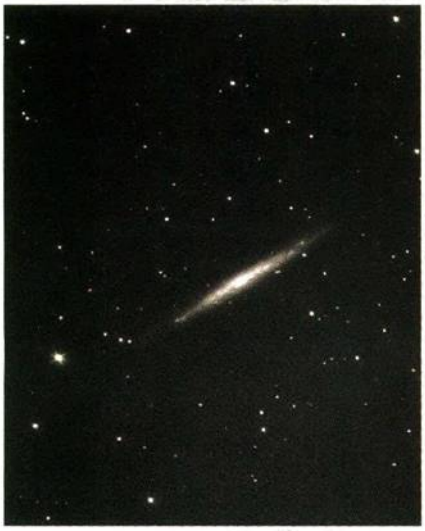
"Martian Life" is hot.
Government cash to be had.
"Cold Fusion" think not.

Peritsky adds that his poetic inspiration comes from the "tenth muse, Hype" whose "symbol is the press release." □

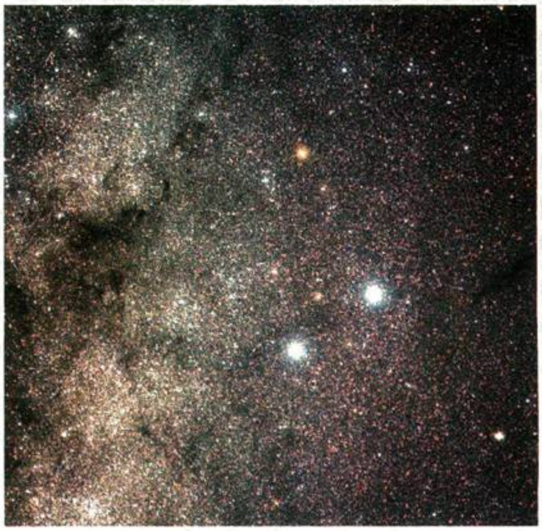
ASTRONOMY wants to share your observations of the sky with readers. Send reports, sketches, photographs, and disks to John Shibley, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Please label each photo with photo data, name, address, and social security number. You may send written reports and images via the Internet to: rreports@astronomy.com



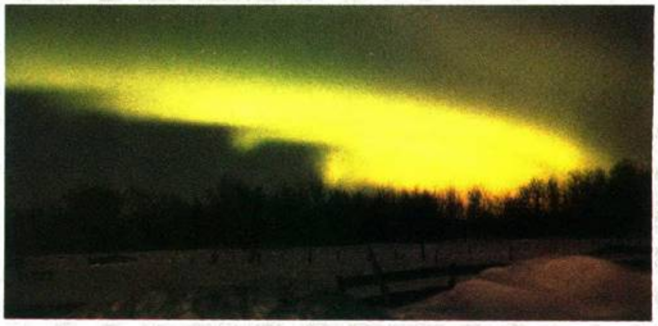
Comet Hyakutake and Mir/Space Shuttle Atlantis, March 27, 1996
Tom Ritland
(16mm f/2.8 lens, Fujicolor 1600 film, 10-minute exposure)



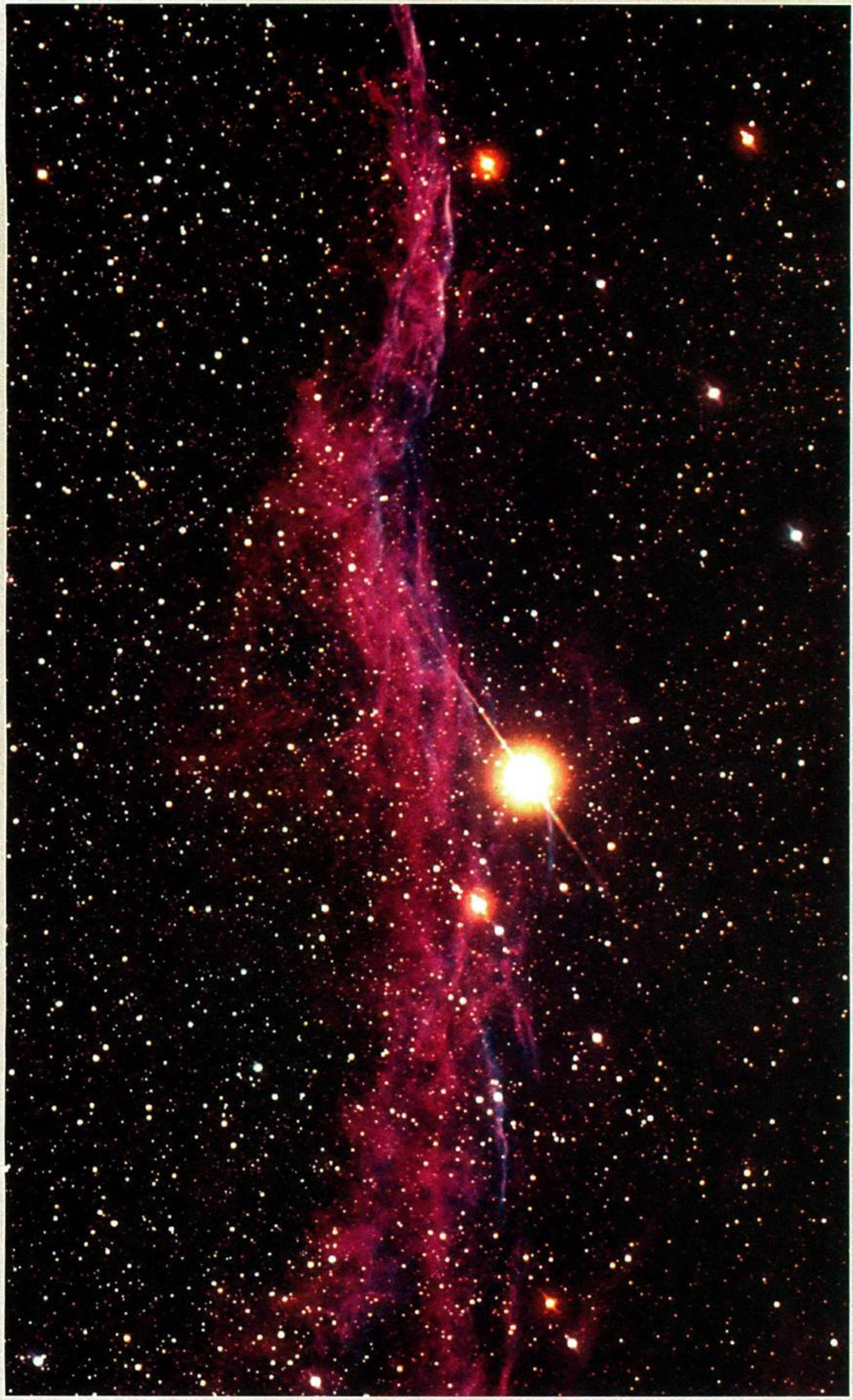
Galaxy NGC 4244 in Canes Venatici
Chris Schur
(12.5-inch f/5 reflector, hypered Tech Pan film, 60-minute exposure)



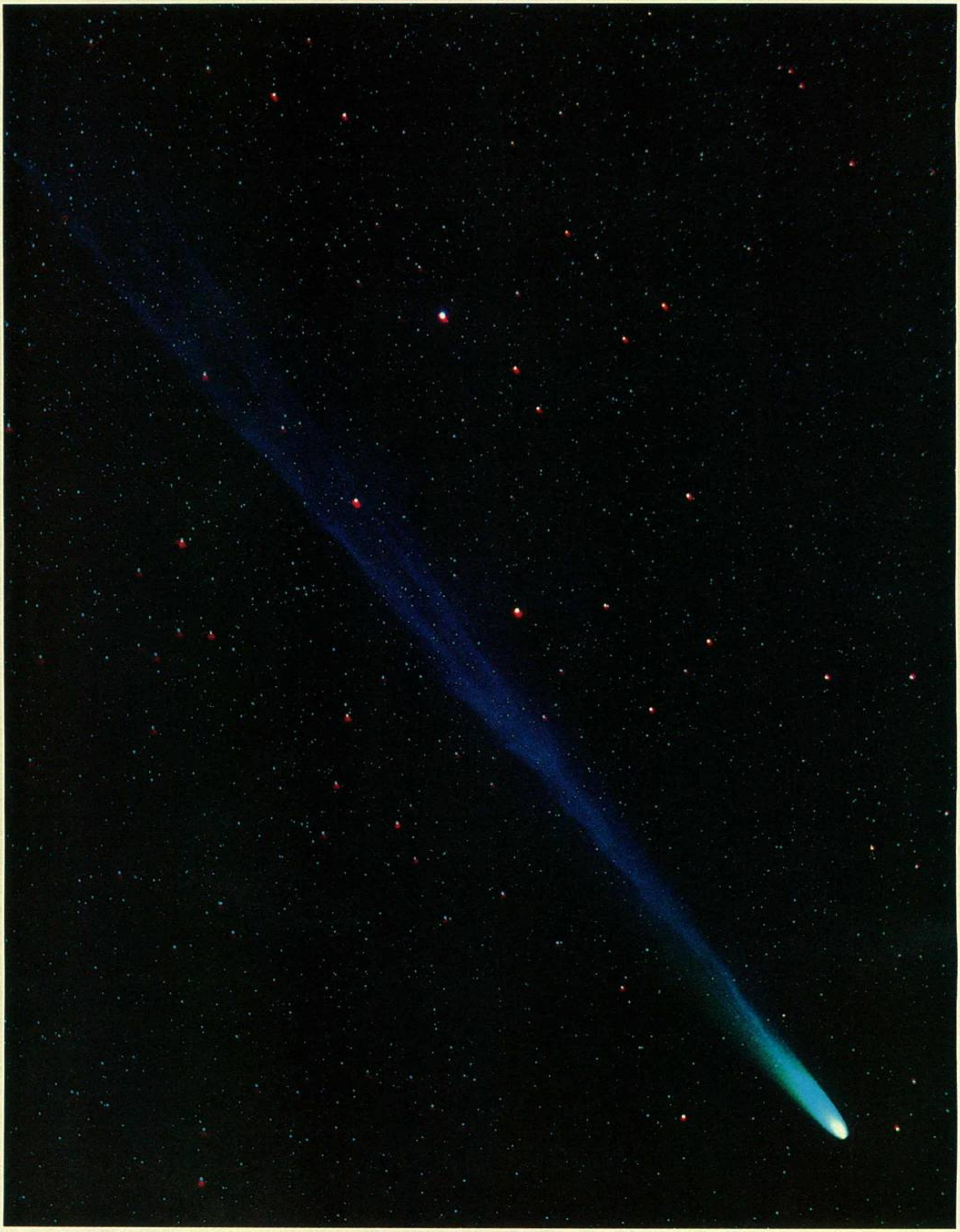
The Southern Constellation Musca
Luke Dodd
(300mm f/4 lens on a Pentax 67, hypered Fujicolor 400 film, composite of two 20-minute exposures)



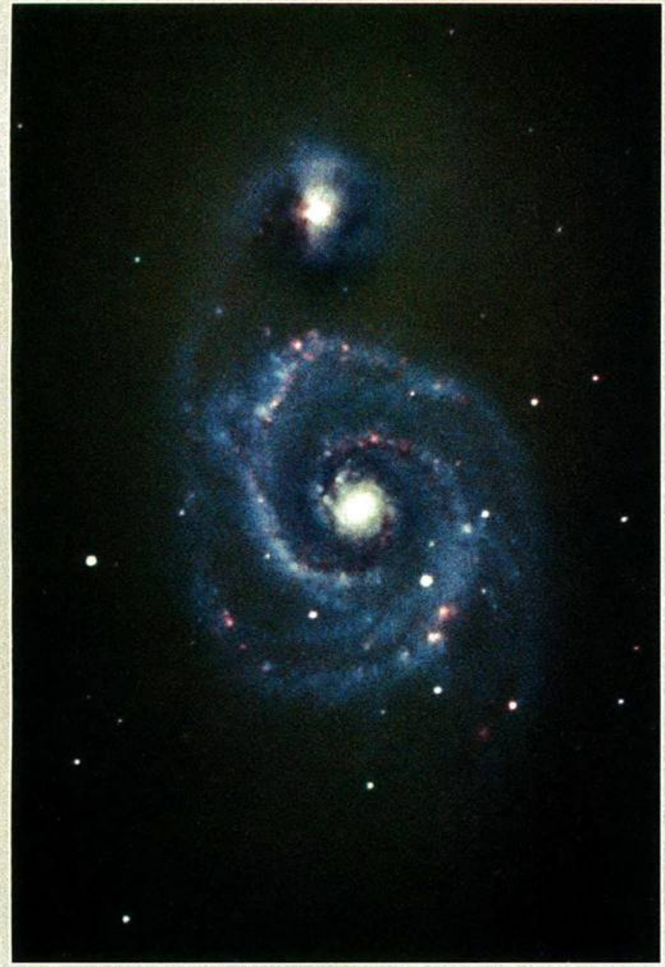
Aurora over Manitoba
Brent Anderson
(50mm f/1.8 lens, Fuji Super 1600 film, 10-second exposure)



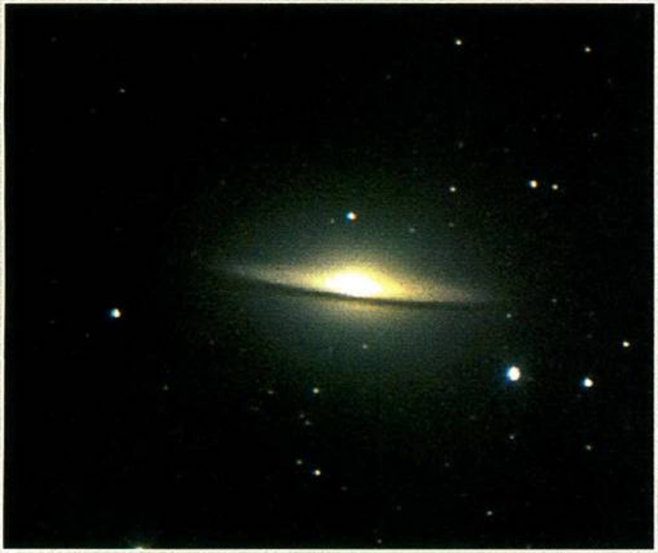
52 Cygni and the Veil Nebula
Bill and Sally Fletcher
(16-inch f/4.5 reflector; tricolor exposure on hypered Tech Pan film)



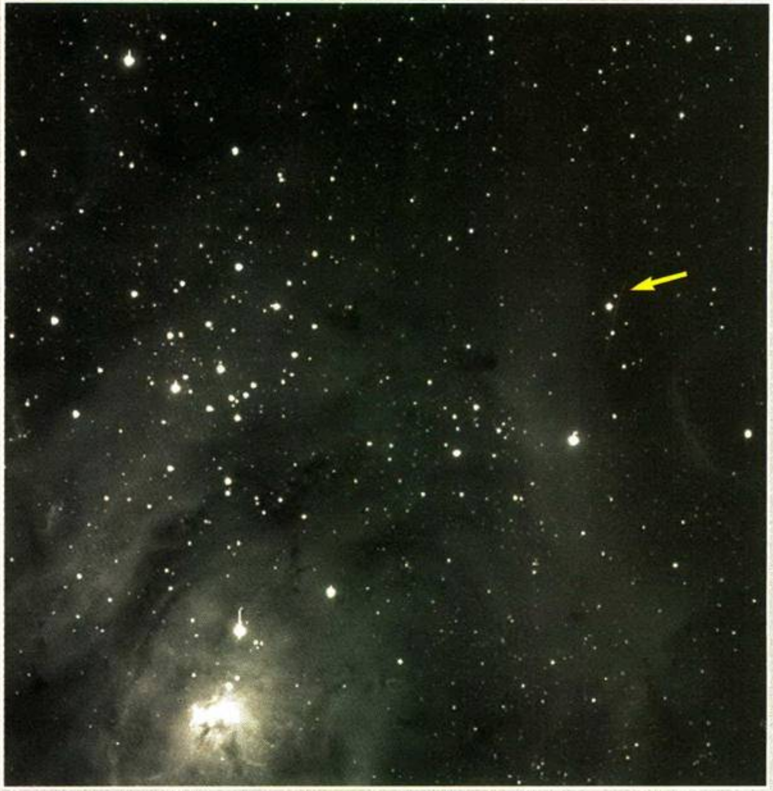
Comet Hyakutake on May 18, 1996
Rev. Ronald Royer
(4-inch f/5 lens, tricolor exposures on 4x5 spectroscopic plates and Tech Pan film)



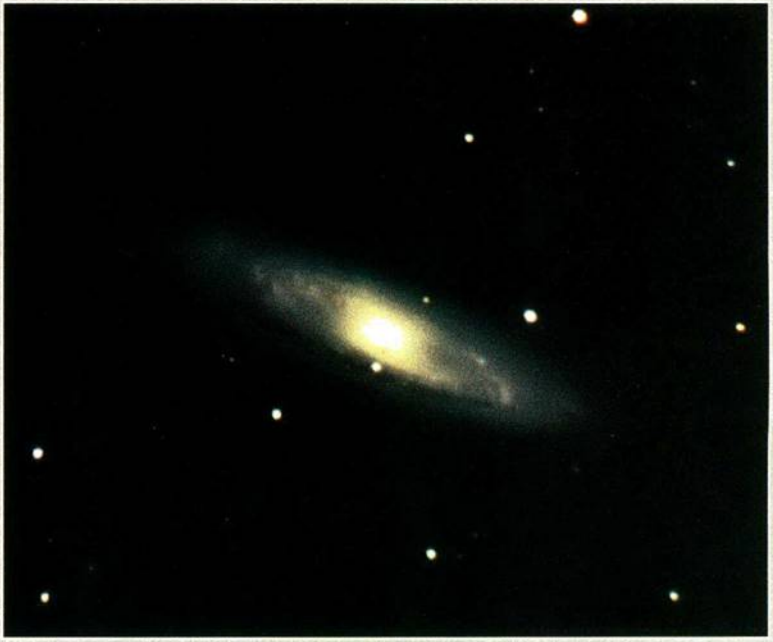
The Whirlpool Galaxy (M51)
Ken Blankenship and Dennis Batis
(14-inch f/7.5 reflector, Fuji Supreme HG 200-II film, 10-second esposure)



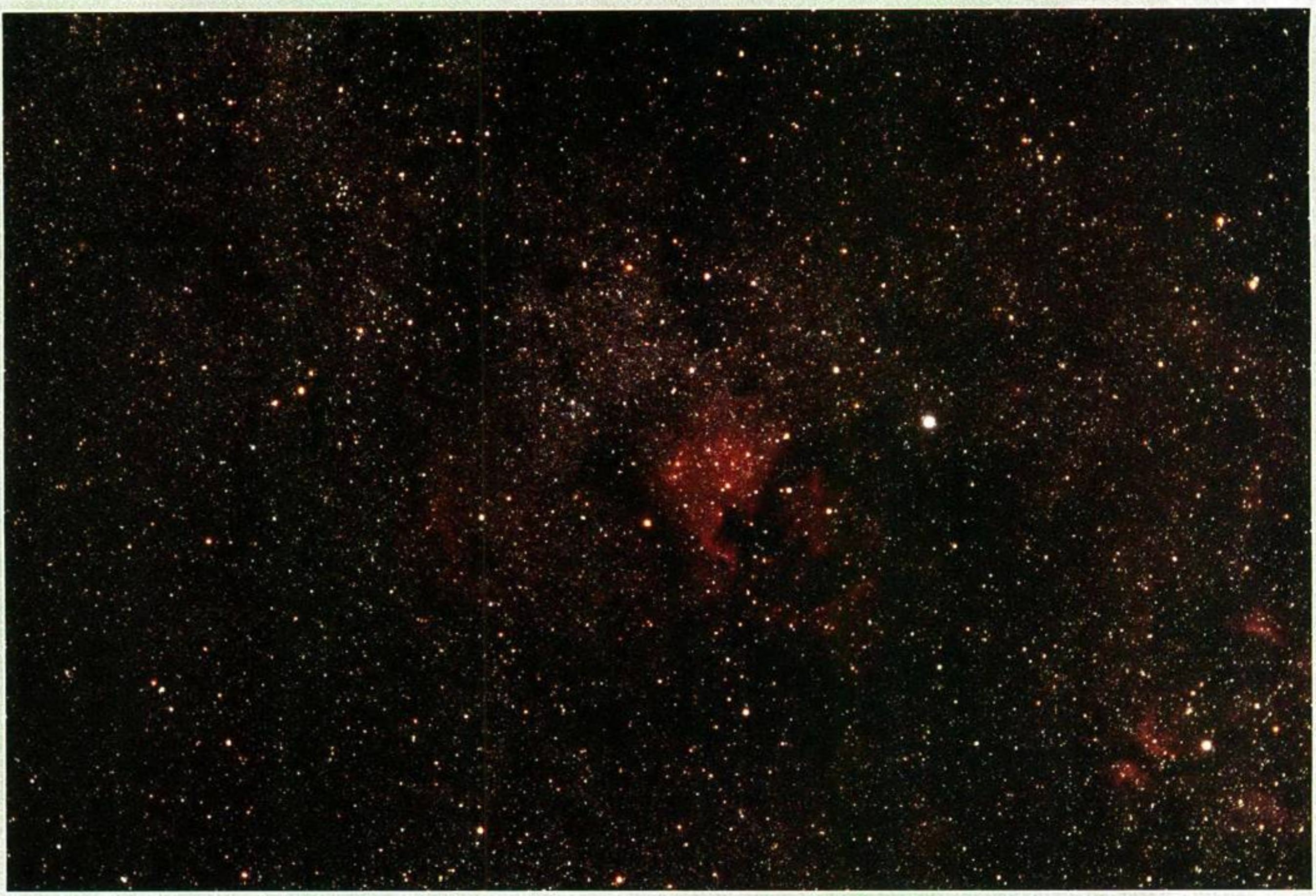
The Sombrero Galaxy (M104)
Jim Hunter and James McGaha
(24-inch f/5 reflector; Tricolor CCD)



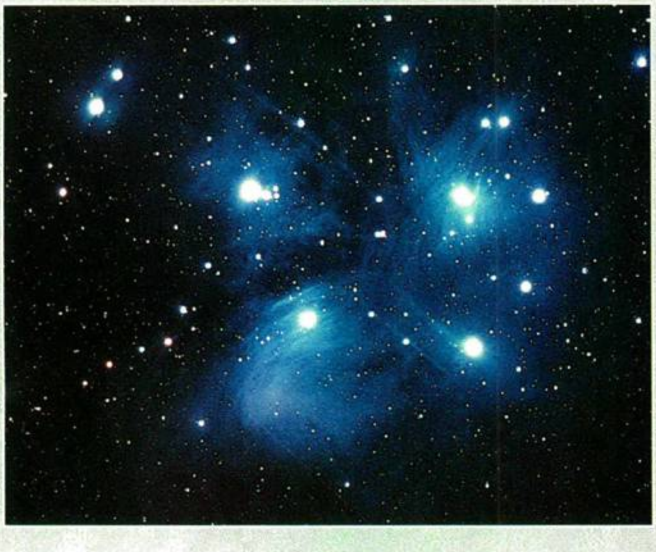
Lagoon Nebula and Asteroid Icarus
Claudio Botarri
(7-inch f/9 refractor, CCD camera, 20-minute exposure)



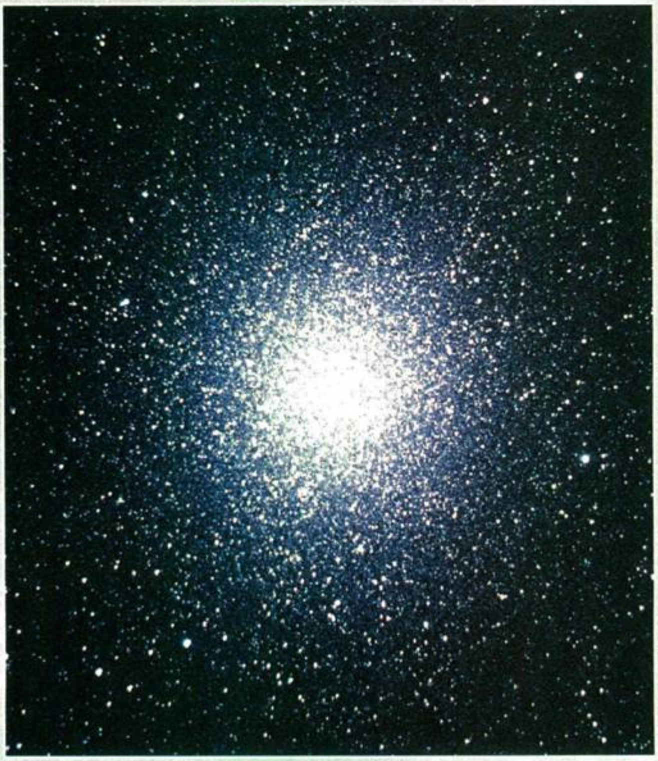
Spiral Galaxy M65 in Leo
Jason Ware
(16-inch f/10 Schmidt-Cassegrain, hypered Fuji G800 film, composite of two 60-minute exposures)



The North America Nebula
Giovanni Andreis
(105mm lens at f/4, Ektachrome P1600 film, 10-minute exposure)

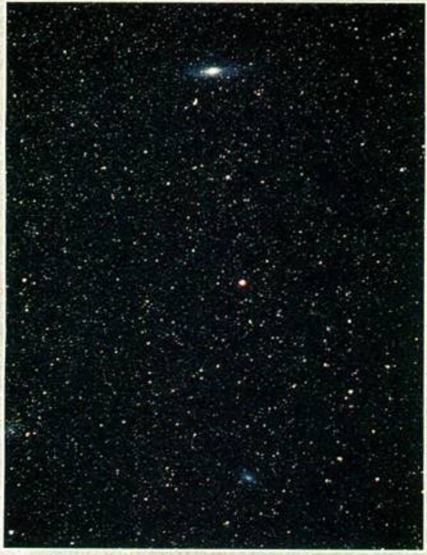


M45, The Pleiades
Tony and Daphne Hallas
(7-inch f/7 refractor, hypered Fuji Super HG400 film, composite of two 45-minute exposures)

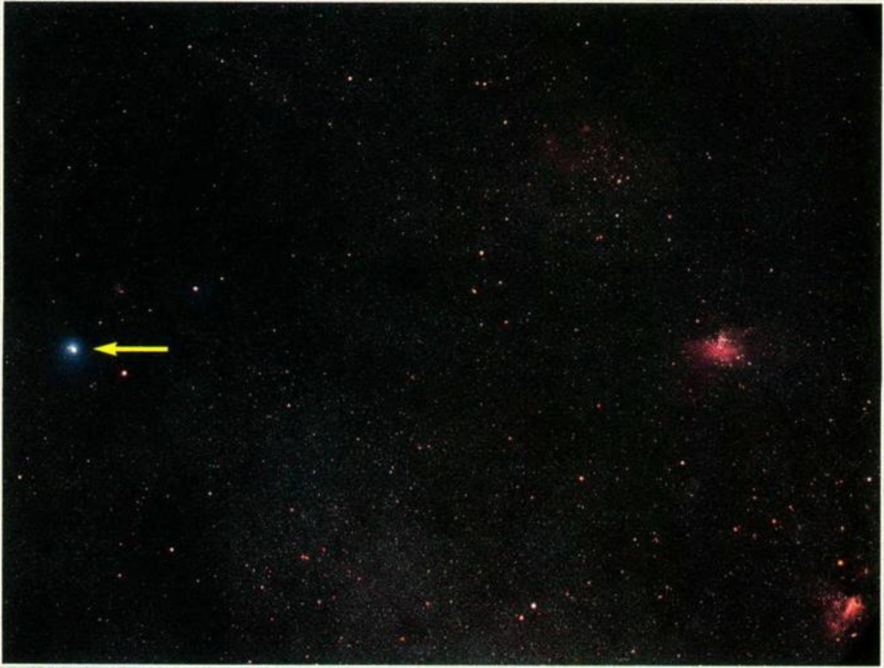


Omega Centauri
James R. Foster
(11-inch f/11 reflector, hypered Fuji HG400 film, 85-minutes exposure)

Gamma Cygni Region
Vince and Maggie Farnsworth
(4-inch f/5 refractor, Fuji SG 800 film, composite of two 45-minute exposures)



Spiral galaxies M31 (top) and M33
Jerry Schad
(85mm lens at f/1.7; Ektachrome P1600 film pushed to ISO 3200, 10-minute exposure)



M16, M17, and Comet Hale-Bopp on June 15, 1996
Bill and Sally Fletcher
(5.5-inch Schmidt camera, hypered Kodak Royal 100 film, 12-minute exposure)

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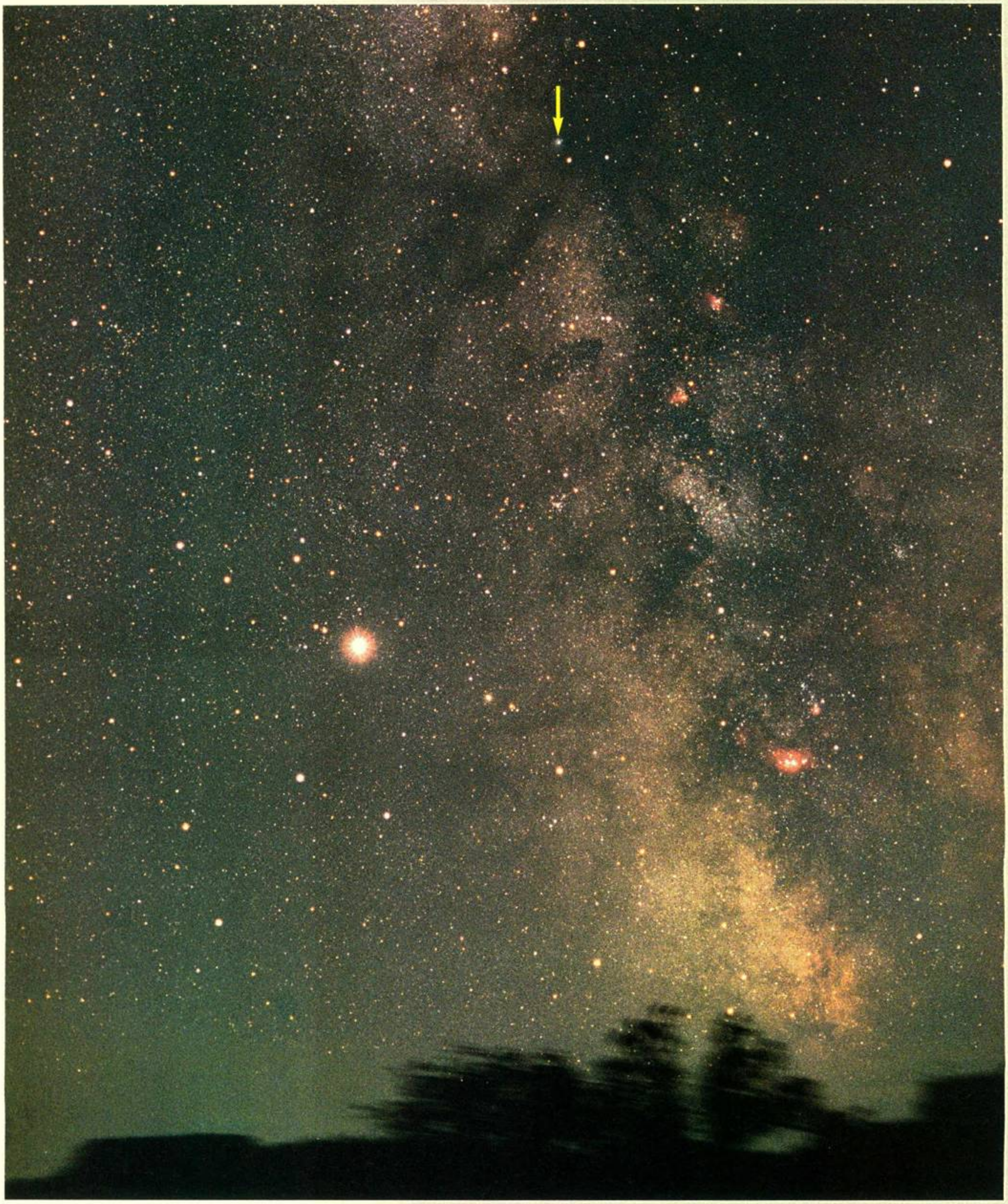

Summer Milky Way and Comet Hale-Bopp on July 13, 1996
Gerald Rhemann and Franz Kersche
(50mm lens at f/2, Kodak Gold Pro 400 film, 5-minute exposure)

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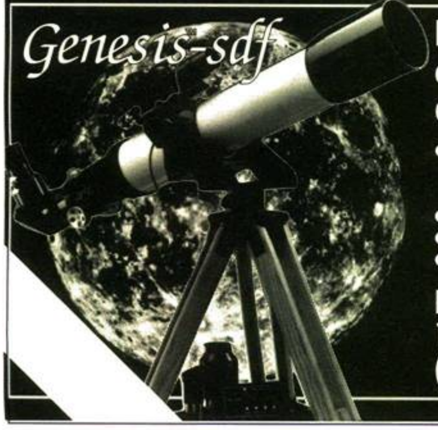

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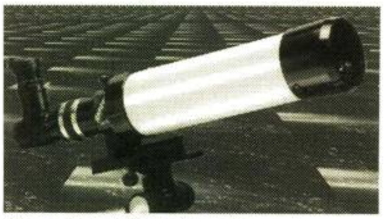

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WASHINGTON

Captain's Nautical Supplies
-EST. 1897-
Complete line of **Tele Vue®** telescopes and eyepieces.
Expert optical instrument repair.
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TELE VUE...TOPS IN THE FIELD

NAGLER

82° Nagler Eyepieces

The "spacewalk" eyepiece! Patented & tested to be the best! Fully multi-coated, eyeguards. 20, 16, 13, 12, 9, 7, 4.8mm

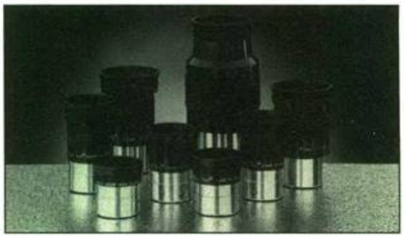
PANOPTIC

68° Panoptic Eyepieces

New world standard in wide angle eyepieces. Fully multi-coated, eyeguards, grip rings. 35 & 27, 22 & 15mm

PLÖSSL

50° Plössl Eyepieces



Preferred Plössl in S&T comparison review. Fully multi-coated, patented Nagler design. 55, 40, 32, 25, 20, 15, 11, 8mm

PARACORR

Newtonian Coma Corrector

Paracorr corrects coma and flattens the field of "DobNewts," increases diffraction limited field area by 36 times and slips into a 2" focuser like a Barlow! Essential for f/4 — f/5 scopes. See perfection emerge.

BINO VUE

Two eyes are better than one

Bino Vue features in-line viewing for terrestrial and astronomical observing, no focus shift during inter-ocular adjustment, large, multi-coated prisms and Tele Vue quality control. Dramatically transforms any scope!

BARLOWS

Magnification Windows

Nagler designed for optimum performance. NO aberrations, just magnification! 2x & 3x (1¼"), 2x (2") with captive screw & parfocal 1¼" eyepiece adapter. Fully multi-coated and threaded for filters.

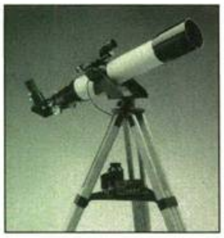
ACCESSORIES

Diagonals, Prisms, Adapters

Tele Vue offers high quality, enhanced aluminum mirror diagonals in 1¼" & 2" formats, 45° & straight-thru image correcting prisms, 35mm camera adapters for 1¼" & 2" focussers and eyepiece adapters for .965, 1¼" & 2" formats.

GIBRALTAR/SKY TOUR

Solid, Portable & Wired



Rock-solid wood tripod with alt-az head. Sky Tour computer available for finding and identifying 2000 objects selected by author Tom Lorenzin. Great with all Tele Vue scopes. Full object listing included.

FINDERS

Starbeam & Qwik-Point

Star-hop across the sky with Starbeam and Qwik-Point "red-dot" finders. Starbeam features a large 40mm lens, variable brightness, elegant design and all metal construction. Qwik-Point offers day & variable night brightness, light weight & exceptional value.

Tele Vue is proud to deliver fellow amateur astronomers a selection of the finest eyepieces, telescopes and accessories. Our enthusiasm for astronomy is carried into our products; adding thoughtful touches such as anti-reflection threads on internal barrel surfaces, captive screws where possible and safety undercuts to name a few. Tele Vue products are designed, manufactured and tested to be fully appreciated in the field. Discover the Tele Vue experience!

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Product flyer free or send $3 for full-line literature.
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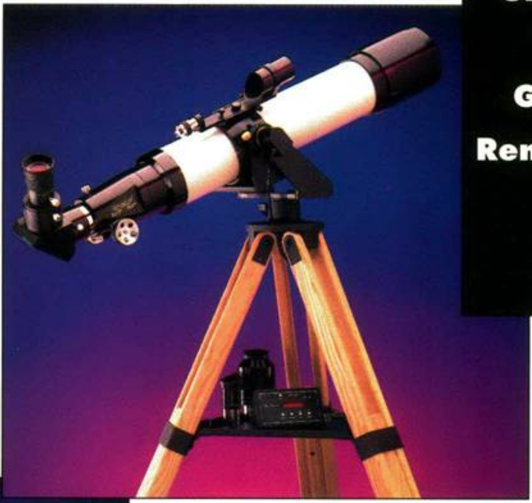
Tele Vue Optics, Dept A, 100 Route 59, Suffern, NY 10901. (914) 357-9522.

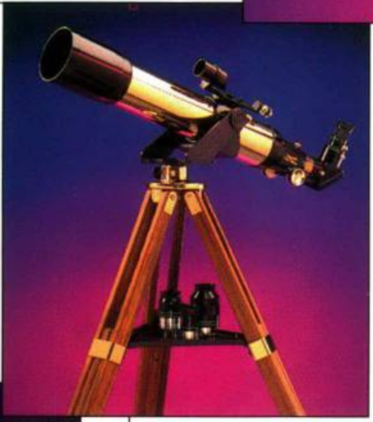
TELE VUE REFRACTORS

Unforgettable images...both rich-field & diffraction limited...pride of owning a fine piece of American craftsmanship...convenience; These unsolicited sentiments plus those below have been expressed by so many Tele Vue telescope owners. Our goal is to produce scopes rich in value, so you may enjoy exploring all facets of your universe. Call your dealer today and begin an unforgettable journey.



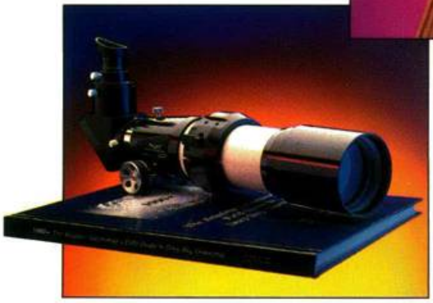
Unforgettable Images.
Genesis-SDF
Renaissance-SDF
Pronto
Ranger

SDF - 101mm Ap., f/5.4 APO
Pronto - 70mm Ap., f/6.8 E.D.
Ranger - 70mm Ap., f/6.8 E.D.



GENESIS/RENAISSANCE-sdf

"...On critical star tests, the Genesis-sdf performed flawlessly...The level of color correction in the SDF was impressive. The edge of the Moon was pure white. Saturn appeared without any trace of a blue halo. This is a superb level of color correction in any refractor, let alone one this fast and portable... Combined with premium wide-angle eyepieces, this is a telescope capable of providing stunning low-power views of Milky Way starfields. And yet under good seeing conditions, the sharp optics will easily handle 200 to 250 power." — Astronomy



I'm amazed at the views! Workmanship excellent - my 8" SCT will gather dust!! R.L. - NH

Wanted high performance APO-Fluorite refractor for wide field views with ultra sharp stars. A fantastic little refractor telescope that I enjoy using more than any other telescope I've ever owned Thank you. JB. - Australia

Probably slightly better than Zeiss APQ, and the one with largest aperture that can be moved by one person only. It's really marvellous. W.D. - Germany

PRONTO

What a great little scope! I found M97, M108, NGC4361, NGC2997& NGC2438 — all from the suburbs. Open clusters look better in my Pronto than in any scope I've ever used. A.E. — AZ

Wow! Perfection in design & quality. Images I only dreamed of. Given a choice of reflectors twice the size, I'll take Pronto. L.R. — CO

The ultimate "shoot & scoot" scope! M.L. — Ont.

Tired of heavy, computerized, SCTs & spending time with them rather than stars. Superb!! Flawless design & performance. What a joy to use. Thanx Al. M.F. — NY

Good sharp view of the Moon & comet Hyakutake. The S&T review persuaded me that going for quality would be good. R.F. - MO

RANGER

" We put Tele Vue's new 70mm f/6.8 refractor through its paces and discovered an ideal travel telescope for astronomy, wildlife, or sports... Saturn's moon Titan as a pinpoint, and a clear edged planetary disc of pale beige yellow with hazy equatorial banding...the tiny, elaborate trapezium of M29 stood out clearly...the companions of Andromeda, M32 and NGC205 showed clearly...the northern component of the Double-Double showed plenty of black space" — Sky & Telescope

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Celestron® CG-9¼

The first truly new size in Schmidt-Cassegrain telescopes in over 20 years!

The **CG-9¼** introduces a **new** and **unique** large aperture Schmidt-Cassegrain telescope. It provides a 34% increase in light gathering power over 8" telescopes. It is a 2350mm focal length telescope at f/10.

The CG-9¼ combines the unequaled optical excellence of the **Celestron 9¼"** Schmidt-Cassegrain with a superb German equatorial mount built for **Celestron** by Losmandy. This combination was built for the more serious astronomer who wants the maximum in rigidity.

The all-machined equatorial mount is a work of art. Both axes are driven by a 2.8" diameter, 180-tooth worm gear.

The R.A. and DEC assemblies incorporate two thrust bearings each. These axes are preloaded for zero play and variable friction clutched by a single knob. The 3½" diameter laser engraved precision setting circles are readable to ¼ degree in DEC and four minutes in R.A. The R.A. circle is direct reading indexed to the R.A. gear motion. All these technical features deliver the smoothness, refinement, controllability and precision that you've always wanted in a fine mount.

The CG-9¼ dual axis DC electronics are state-of-the-art. Four tracking rates are available: sidereal, King, lunar and solar. It has four setting rates of 4x, 8x, 16x and 32x. Also it has three photo guide rates of ±30%, ±50% and 2x. The electronics have full feature PEC (Periodic Error Correction) built-in. TVC (Time Variable Constant) built-in is a user programmable declination backlash compensation for instantaneous tracking response. *Sky & Telescope* said, "the drive is so accurate that tracking was superb whether or not the electronic PEC feature was switched on."

The equatorial head weighs 21 lbs. without counterweight bar and is the heaviest individual component of this portable telescope. Total weight is 53 lbs.

The mount has an optional polar alignment scope available which works in both hemispheres. The latitude range is 0° to 64°.

With the addition of the optional Advanced Astro Master®, you have a computerized telescope.

Standard accessories included are: 6x30 Finderscope, Star Diagonal – 1¼", and a multi-coated 26mm Plössl Eyepiece – 1¼" (90x). Starbright® coatings are included.

Comes standard with a unique focusing micrometer for ultra precise focusing for CCD imaging or astrophotography.

CELESTRON GERMAN MOUNT SCHMIDT-CASSEGRAIN TELESCOPES:

CG-11–An 11" (279mm) telescope with a focal length of 2800mm (f/10). It provides a significant 21% increase in light gathering power over 10" telescopes and 89% more than 8" telescopes.

It has a larger and heavier duty equatorial head than the CG-9¼. Both axes are driven by a 5.6" diameter, 360-tooth worm gear.

Electronics are similar to the CG-9¼.

The equatorial head weighs 31 lbs. and is the heaviest individual component of this portable telescope. Range 12° to 64°.

The rugged aluminum adjustable height tripod has 3" diameter legs, is 48" long and weighs 20 lbs.

Standard accessories include a 7x50 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼" and a multi-coated 26mm Plössl Eyepiece – 1¼" (108x).

CG-14 – A 14" (356mm) telescope. It has a focal length of 3910mm and a focal ratio of f/11.

The German equatorial mount is the same as supplied with the CG-11 telescope but with additional counterweights.

This large aperture professional-type instrument is portable enough to easily transport for serious astronomical work. Experience incredible scientific research optical performance and awesome views.

The large aperture of the 14" has 306% more light gathering power than an 8" telescope and 96% more than a 10" telescope. Lunar and planetary detail is breathtaking. The tremendous aperture and superb optics combine for thrilling deep-sky observing of diffuse and planetary nebulae, open and globular star clusters, galaxies and binary stars.

Many of the finest amateur astrophotographs have been taken using the C14.

Standard accessories include a 7x50 Finderscope, Star Diagonal – 2" (with a 1¼" adapter) and a 26mm multi-coated Plössl Eyepiece – 1¼" (150x).

GP-C8 – This 8" (203mm) f/10 telescope comes with the Great Polaris mount.

Whether you are looking for a superior first telescope with a traditional German equatorial mount or want to move up to a larger aperture telescope, consider the GP-C8.

Both axes have precision 144-tooth lapped worm gears for very smooth motion. The adjustable height, very rigid wood tripod has excellent vibration dampening characteristics and has a handy accessory tray.

The GP mount has a built-in illuminated polar alignment scope for fast polar alignment.

The optional Polaris drive controller – a dual-axis motor drive/drive controller – complements the GP-C8. Its advanced motor technology utilizes DC servo motors with remarkable high efficiency allowing the system to be powered by a tiny 9-volt alkaline battery that lasts more than 48 hours! A manual clutch assembly override is convenient to use.

With optional accessories, the GP-C8 easily converts to a computerized telescope.

Standard accessories include a 6x30 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼", and a 26mm multi-coated Plössl Eyepiece – 1¼" (78x). Weight of the complete telescope is 45 lbs.

CELESTRON® *For more detailed information on these telescopes, contact a Celestron dealer or Celestron.*

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